UNCLASSIFIED

AD NUMBER

AD529945

CLASSIFICATION CHANGES

TO: unclassified

FROM: confidential

LIMITATION CHANGES

TO:

Approved for public release, distribution unlimited

FROM:

Distribution authorized to U.S. Gov't. agencies and their contractors; Other requests shall be referred to Office of Naval Research, Washington, DC

AUTHORITY

1980 GDS-document markings; ONR ltr., Ser 93/160, 10 Mar 1999

THIS PAGE IS UNCLASSIFIED

CONFIDENTIAL ACR-196

AD529945

PROJECT PACIFIC SEA SPIDER

Technology Used in Developing a Deep-Ocean Ultrastable Platform

[Unclassified Title]

JOHN B. GREGORY

April 12, 1974

OFFICE OF NAVAL RESEARCH
DEPARTMENT OF THE NAVY
Arlington, Virginia

CONFIDENTIAL

CONFIDENTIAL, classified by CNR
Subject to GDS of E.O. 11652
Auto. declassified Dec. 31, [illegible]

NATIONAL SECURITY INFORMATION

Unauthorized Disclosure Subject to Criminal Sanctions.

CONFIDENTIAL

SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER ONR Report ACR-196	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER
4. TITLE (and Subtitle) PROJECT PACIFIC SEA SPIDER — TECHNOLOGY USED IN DEVELOPING A DEEP-OCEAN ULTRASTABLE PLATFORM (U)		5. TYPE OF REPORT & PERIOD COVERED Final report on the project 6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s) John B. Gregory		8. CONTRACT OR GRANT NUMBER(s)
9. PERFORMING ORGANIZATION NAME AND ADDRESS Office of Naval Research Arlington, Virginia 22217		10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS
11. CONTROLLING OFFICE NAME AND ADDRESS Department of the Navy Office of Naval Research Arlington, Virginia 22217		12. REPORT DATE April 12, 1974 13. NUMBER OF PAGES 53
14. MONITORING AGENCY NAME & ADDRESS(if different from Controlling Office)		15. SECURITY CLASS. (of this report) Confidential 15a. DECLASSIFICATION/DOWNGRADING SCHEDULE GDS-80

16. DISTRIBUTION STATEMENT (of this Report)

None

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Stable moors
Instrumented moors
Deep ocean moors
Acoustic surveillance

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

(Unclassified)

Along tripod legs of standard coaxial cable to be anchored 19,000 feet deep were 30 hydrophones, 12 temperature sensors, several engineering sensors, and 3400 10- and 16-inch glass buoyancy elements. Electronic packages with the sensors were to multiplex signals along the cable, avoiding the weight and handling problems of separate conductors. At the apex a subsurface buoy to stay within diver depth contained signal-conditioning and control electronics

(Continues)

20.

and three radioactive thermoelectric generators. A surface buoy on a rubber pendant was to transmit VHF and HF telemetry to a ship and to shore. Implantment was attempted unsuccessfully from a stable, maneuverable, offshore-oil-rig supply boat. Powered cable-tensioning winches streamed each leg outward from the surface-moored subsurface buoy and then lowered the anchor on an expendable crown line. Anchoring the third leg would also have pulled down the subsurface buoy. The primary cause of failure was the firing of an anchor release during implantment. Subsequent damage to the cables resulted from storm conditions which arose. Future moors require more work on light strong cable, reliable electrical terminations bondable to polyethylene dielectric cable material, and light hydrophone/electronic assemblies which are isolated from vibration of the cable.

CONTENTS

CONFIDENTIAL

PROJECT PACIFIC SEA SPIDER – TECHNOLOGY USED IN DEVELOPING A DEEP-OCEAN ULTRASTABLE PLATFORM
[Unclassified Title]

INTRODUCTION

(C) Pacific Sea Spider (Fig. 1) was a deep-ocean instrumented three-point moor developed for the Navy's Long Range Acoustic Propagation Project (LRAPP). This project required fixed midwater acoustic instrumentation in the severe Pacific Ocean current, 350 miles north of Hawaii, where the prevailing flow to the northeast has superimposed upon it semidiurnal tidal currents [1]. This location and the need for ultra stability were required of the moor so that it could be used in a field experiment of LRAPP known as PARKA (Pacific Acoustic Research Kanehoe-Alaska). In its formative concept Pacific Sea Spider was to be elementary in design, because it was realized that the successful implantment of such a moor had not been demonstrated to be within the state of the engineering art. However, as the scientific community formulated its plans, additional requirements for acoustic instrumentation, calibration, and telemetry were added, so that ultimately the moor was quite complex. In addition budgetary and scheduling limitations required that hardware design and implantment use existing technology.

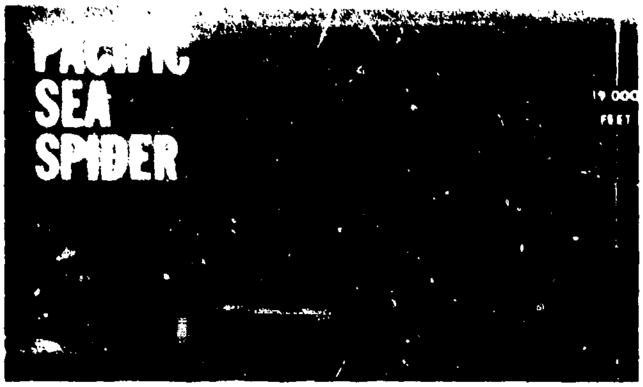
(U) Ultimately some combination of these factors contributed to an unsuccessful attempt to install the structure in the ocean. However this documentation will assist engineers who will be involved in the design and implantment of similar future moors. The main sections of this report describe the major subsystems of the Pacific Sea Spider: hydromechanical, electronics, and implantment. Prior to these sections, the next section provides a short summary and recommendations.

(U) The author is indebted to Robert Martin of the Naval Underwater Systems Center, New London Laboratory, for writing the Electronic Subsystem section.

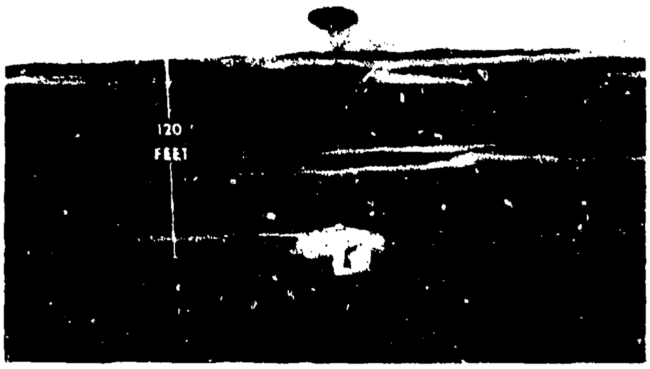
SUMMARY AND RECOMMENDATIONS

(U) • The design of Pacific Sea Spider was predicated upon the general configuration and detailed performance specifications furnished by the Office of Naval Research. To meet these requirements and to provide a system which was judged most manageable to deploy at sea, it was necessary to use single coaxial leg cables and to provide signal-conditioning electronic packages at the underwater sensor locations. Because of the high quality control of present-day electronics, it was determined that the inaccessibility of these packages would not adversely affect the life of the sensors on the legs.

(U) • A 14-1/2-foot-major-diameter oblate-spheroidal subsurface buoy provided 26,000 pounds of net buoyancy. Inside the buoy were three 25-watt thermoelectric isotope generators, each of which weighed 3400 pounds, and canisters of signal-conditioning and control electronics. A diver access hatch at the bottom provided for servicing the electronics. Diver-training exercises showed the configuration to be suitable.



(a) Overall moor



(b) Apex of the moor

(U) Fig. 1 — Pacific Sea Spider in the implanted configuration

(c) Bottom contour

(U) Fig. 1 (Continued) — Pacific Sea Spider in the implanted configuration

(U) ● Array legs were double-armored-steel single-coaxial cable which exhibited sufficient stiffness under the upward thrust of the subsurface float to provide the required motion stability. Torque properties of the cable were high, but more suitable strong small-diameter cables of other designs were nonexistent.

(U) ● Cable buoyancy was provided by means of 10- and 16-inch-diameter glass buoyancy elements. No difficulties were experienced handling the smaller balls, but the larger ones were heavy and were affixed to the cable by pendants, both of which factors caused them to break free from the action of the sea.

(U) ● Preformed Line Products Company Dynagrip mechanical terminations proved excellent. Electrical appendages on the legs were molded ashore and stowed on the cable reels at sea. The development of a high-reliability plug-type electrical termination suitable for polyethylene-jacketed cable systems would have proven of great benefit to the project.

(U) ● Anchors were large clumps, which were lowered without incident by means of steel nontorquing 3 by 19 crown lines.

(U) ● Sea Spider instrumentation consisted of 30 hydrophones, 12 temperature sensors, and several other engineering sensors. When they were operating, their outputs modulated individual voltage-controlled oscillators which differed from one another in their center frequencies. These modulated signals were then multiplexed onto coaxial leg cables and telemetered to the subsurface buoy. In the buoy each signal was translated to one of 15 preselected frequencies which then were translated to individual VHF carrier

frequencies and transmitted from the surface telemetry buoy to a nearby ship. An HF transmitter was also contained in the surface buoy for broadcast of certain state-of-moor data to a remote station in event a monitor vessel was not in attendance.

(U) • Primary power for the electronic system was derived from three 25-watt radioisotope thermoelectric generators. These generators charged storage batteries through a dc-dc connector.

(U) • The dynamic range of the acoustical subsystem was specified to be 70 dB. Measurements taken in port were as high as 65 dB but may have been hampered by excessive radio noise in the vicinity.

(U) • Implantment of Pacific Sea Spider was predicated on the use of a single work vessel, day and night continuous operation, diver assistance, and low sea states.

(U) • The *Rigbuilder*, the implant vessel, carried 420 tons of equipment to sea. Though her decks were crowded with gear, she proved a capable vessel for the operation. Extra berthing spaces were provided by assist ships, and the use of rubber boats for personnel transfer proved highly efficient. A backhoe was converted for use as a heavy lift crane. Though new, it had less than desirable control.

(U) • Moor center was established by means of a satellite navigator. For the implant operation a subsurface taut moor, having surface expression, was implanted for visual purposes. In addition, three transponders on the ocean floor provided acoustic positioning information. To improve accuracy, future implant attempts should consider navigation systems which locate underwater equipment instead of limiting the navigation to the positioning of ships on the surface.

(U) • The basic method of deploying the tri-moor was to moor the subsurface buoy on the surface and to stream the three legs radially outward on the surface, sequentially lowering each anchor. The third leg was to be lowered in such a manner as to pull the subsurface buoy to design depth. The simplicity of this approach as well as most of its elements recommend its consideration for future implants. However future moors should provide a means for storing and damping the energy of the sea, which tends to snap and twist cables during deployment.

(U) • Most of the hardware used in the moor and its auxiliary equipment appeared oceanworthy. However the electromechanical leg cables, with their cumbersome hydrophone assemblies, were difficult to deploy. In this context development work should continue on attaining small-diameter strong lightweight cable, reliable electrical terminations for underwater usage which can be bonded to polyethylene dielectric cable material, and lightweight hydrophone/electronics assemblies which are vibration isolated from the cable system.

(U) • Experience gained from two successive implant attempts indicates that future deep complex moors should be designed as light as practicable.

INTRODUCTION TO DESCRIPTION OF THE MAJOR SUBSYSTEMS

(U) The Pacific Sea Spider was a moor with three anchor points forming an equilateral triangle on the ocean floor and three legs at 45 degrees to the floor buoyed at their apex by a large float 120 feet below the ocean surface. A surface buoy was tethered to the subsurface float by a rubber pendant. The legs were 2/3-inch-diameter double-armored coaxial cables made neutrally bouyant by spacing along them 3400 glass buoyancy floats.

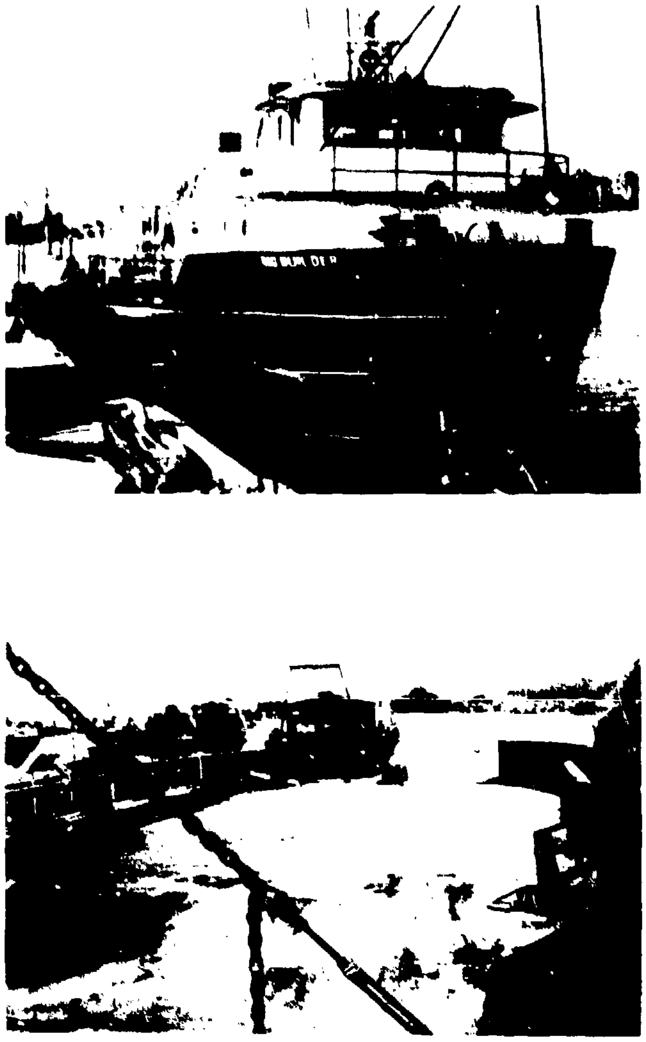
(U) On each leg were a tension sensor (at the top), ten hydrophones, and an acoustic projector (at the bottom) for measuring the spatial positions of the hydrophones. Twelve temperature sensors were distributed on the three legs at selected hydrophone positions. Signals were multiplexed through the leg cables. Depth and current sensors were placed on the subsurface float. Within the float were three radioisotope thermoelectric generators which supplied primary electrical power. Also in the float were canisters containing signal-conditioning electronics for the sensors on the legs. Entwined around rubber pendant that tethered the surface buoy was an electrical umbilical which conducted conditioned signals upward to the telemetry buoy for transmission via VHF telemetry to a nearby ship. HF telemetry also was provided for transmitting certain engineering state-of-moor data to a remote station.

(U) The weight of the moor and equipment necessary to complete its implantment was over 400 tons; almost all of this hardware was carried aboard the implantment vessel, *Rigbuilder*, a 165-foot offshore supply boat (Fig. 2). This type of vessel was selected because of its large open main deck, high power, maneuverability, and stability. In addition to this rather unconventional use of a supply boat, unusual means for paying out cable were employed wherein overhead power cable-tensioning winches were used to lay cables and to lower anchor crown lines. The implanting of Sea Spider was neither a conventional mooring operation nor a cable-laying task; it was a specialized deep-ocean implantment of a complex tensioned structure.

HYDROMECHANICAL SUBSYSTEM

(U) In the design of the hydromechanical subsystem LRAPP scientists required the moor to be stable within the following motion specifications: The subsurface float was specified not to move horizontally more than 20 feet in radius from its no-current condition. In addition no hydrophone was to be misaligned from other hydrophones on the same leg by more than 2.0 degrees. A constraint on the vertical motion of the subsurface buoy, which was to be implanted at about 100 feet, was that the depth not be greater than 125 feet, so that scuba divers could maintain electronics inside the buoy.

(U) To accomplish the design within these constraints, the prime contractor, Interstate Electronics Corporation (IEC), was furnished a tri-moor analysis developed especially for the project by the University of New Hampshire. This quasi-static analysis [2] considered the various physical characteristics such as hydrodynamic drag, cable modulus of elasticity, and current profile. The analysis assumed that the cable would have uniform



(U) Fig. 2 — Two views of the implantment vessel, *Rigbuilder*, prior to project outfitting

mass distribution along its length and a uniform current throughout the water column, the profile for which was approximated by taking the root-mean-square average of the velocity profile.

(U) During the design phase of the Pacific Sea Spider project a second quasi-static analysis and computer program was accomplished by Skop and Kaplan of the Naval Research Laboratory [3]. This analysis mainly differed from the former in that the program was written for a velocity profile consisting of a series of straight-line segments.

(U) Because of the exacting scientific requirement for stability, it was necessary that cable strength-to-weight be maximized and that the leg system be weightless in water. In addition it was necessary to reduce hydrodynamic drag as much as practicable.

(U) The bidder's specifications required that to maximize the reliability of the moor no electronics were to be placed below the subsurface float (below diver depth). This requirement necessarily implied separate electrical conductors for each sensor signal. An exception to this requirement was provided in that, if the bidder could show no degradation in overall system reliability, proposals would be considered wherein electronics were placed near the sensors. By so doing, it would be possible to condition sensor signals on the legs and by multiplex technique lessen the number of conductors in the array cable. Therefore the size and attendant hydrodynamic drag, handling problems, and cost of the cables would be reduced. It followed from this provision that such an alternative would reduce the required subsurface float buoyancy and anchor weight.

(U) The results from computerized analyses of the various proposed designs determined that only by drastically minimizing the electromechanical cable size could the motion specifications be met, and since it was demonstrated by IEC that placing electronics on the legs of the moor did not impair its reliability, it was decided to accept this design philosophy. Thus single-coaxial cable of double-armored steel was selected and instrument packages were placed on the legs at sensor positions to amplify and otherwise condition the signals for multiplexing along the legs to the subsurface float.

Subsurface Float

(U) The subsurface float was designed and constructed by the Rohr Corporation to detailed specifications of General Motors Defense Research Laboratories (DRL), the major subcontractor to IEC for most of the mechanical design and for implantment of the moor.

(U) The buoy (Fig. 3) was an oblate spheroid 14-1/2 feet in diameter and 7 feet high with a comparatively low hydrodynamic drag. Together with its electronic canisters and three 3400-pound radioisotope thermoelectric generators, it provided a net buoyancy of 26,000 pounds. Its weight in air also was 26,000 pounds. Its design internal and external pressure was 200 psig and 150 psig respectively. The buoy was built of 6061-T6 aluminum alloy and subsequently tested hydrostatically to 100 psig. Alloy 6061 was selected because of its well-established resistance to corrosion. However aluminum alloy 5086 was preferred but not available within schedule limitations.

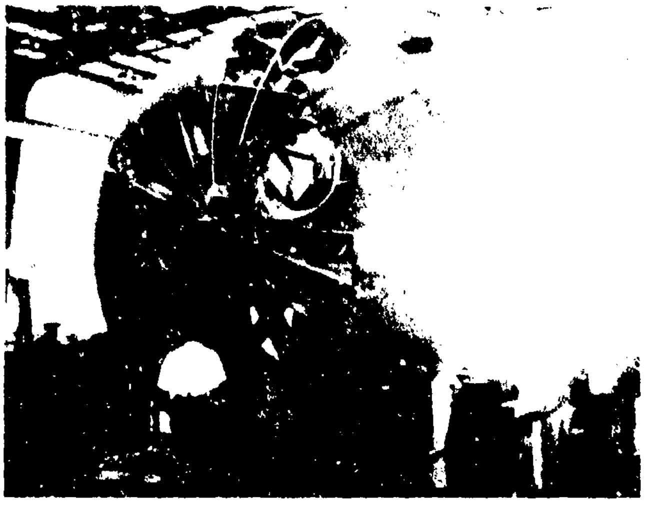
(U) Fig. 3 — Subsurface buoy in its deck transporting cradle with diver ladder and handrails visible including a circular handrail at the bottom

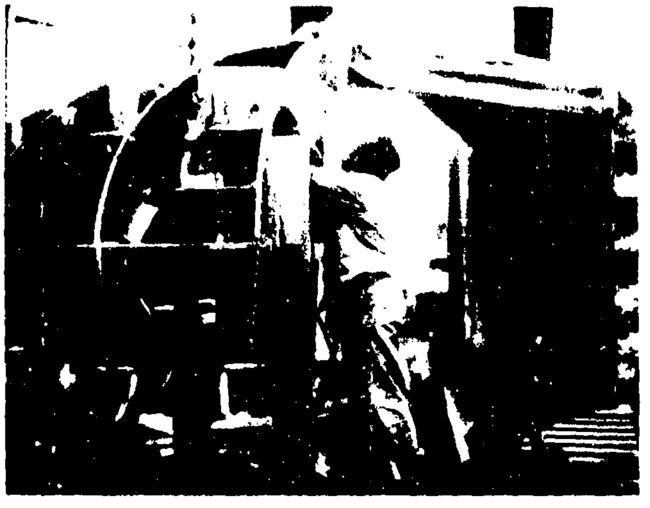
(U) As shown in Fig. 4 the buoy contained nine peripheral pressure-proof wing tanks or voids surrounding the central electronic and power-supply compartment. The voids and the central compartment were pressurized for the implantment depth by means of manifolded piping inside the center compartment of the buoy. Bulkhead stop valves located between the manifold and each individual void were closed to isolate each in case of damage. A remote-reading bourdon-tube pressure gage was located underneath the buoy to enable divers to determine and equalize the ambient and buoy pressure before opening the hatch.

(U) Two hatches were provided in the buoy. Off center, on the top surface, a hatch was located for the singular purpose of loading the three RTGs (Fig. 5). Inside, a portable beam and chain-hoist assembly (Fig. 6) was used to position them onto their mountings. The outer surfaces of the mounting plates were in contact with the sea, so that the generators, which yielded 95-percent-waste heat energy, could be cooled. Figure 3 shows the exterior of one of the three water-cooling scoops, just above the foot of the cradle.

(U) In the center of the bottom of the float a diver entry hatch was provided and was fitted with a swing-down cover which contained rungs to serve as a ladder when the cover (Fig. 7) was open. This cover was fastened by screw-down dogs whose threads were enclosed in a sleeve filled with caster oil to prevent corrosion. During practice diving, with scuba gear, no difficulties were experienced opening or entering the buoy through the hatch.

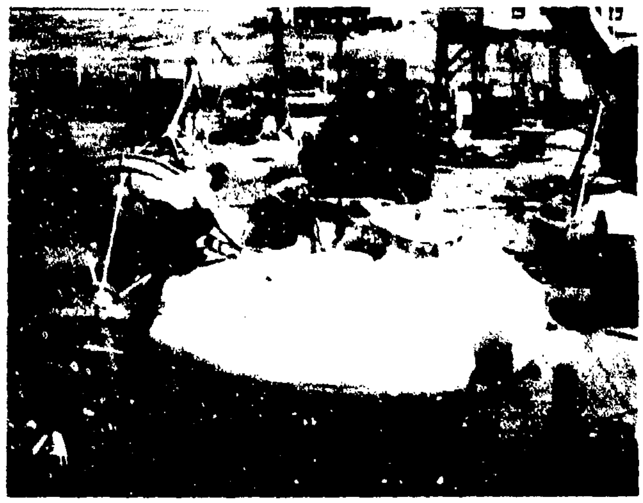
(U) A vertical cylindrical tube or tunnel, which extended completely through one of the voids and was open to the water at each end (next to the ladder in Fig. 3), was provided as a receptical for a self-powered acoustic transponder. The transponder was mounted so that its transducer projected through the underside of the buoy for purposes of locating the buoy when submerged or on the surface. A vessel attempting to locate the buoy would have been provided a portable interrogator for signaling the transponder.



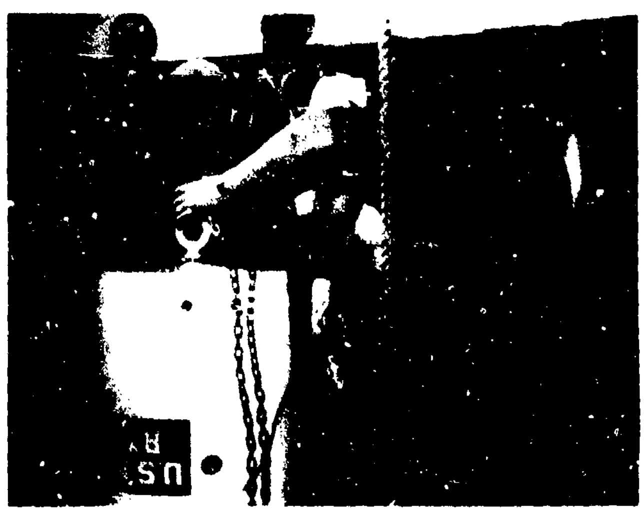


(U) Fig. 4 — Construction views of the subsurface buoy showing a loading hatch (top photo), the large central compartment (bottom photo), and wing tanks

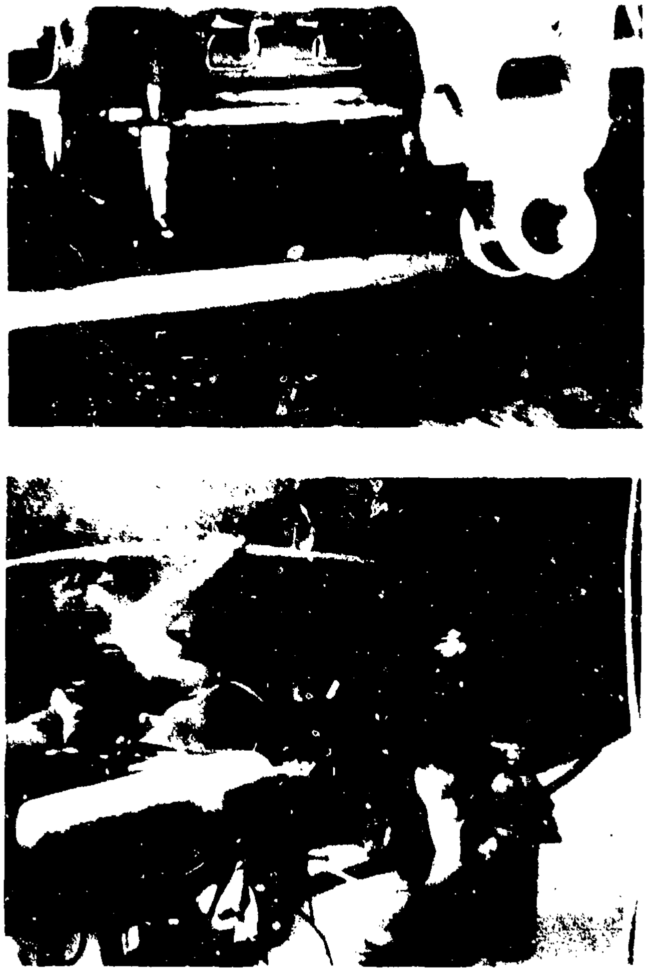
(U) The buoy was designed to be lifted from three lifting lugs symmetrically positioned near the center (behind the offcenter hatch in Fig. 3). On the lugs a removable bracket or yoke was bolted for a single-point lift. Another pad eye was welded to the side of the buoy for towing. The buoy was observed to tow at speeds up to 7 knots without significant yaw or pitch. Underneath the buoy a low-profile, tripodlike cradle (Fig. 3) was bolted to the buoy and to the deck of the implant vessel.



(U) Fig. 5 — Subsurface buoy during loading of the radioactive thermoelectric generators. The hatch cover is not visible; the cover next to the handrail is a faring plate to go over the hatch cover.



(U) Fig. 6 — Portable beam and hoist assembly being used to position a radioactive thermoelectric generator (RTG) onto its mounting plate



(U) Fig. 7 — Diver entry hatch (top center of upper photo) and divers preparing to enter the buoy during deployment

Surface Buoy

(U) The surface telemetry buoy, which is at the left in Fig. 5, and also shown in Fig. 8, was a 7-foot-diameter ellipsoid built of foam-filled fiberglass. In the buoy was a well in which was inserted a canister containing VHF and UHF radio transmitters and a command receiver. A tripod mounted on top of the buoy supported a fiberglass mast for HF telemetry with a smaller antenna affixed above it for VHF telemetry. This small antenna worked loose in the rough seas during the first implant attempt and was not used thereafter. Instead a VHF antenna was fiberglassed to the side of the mast. At the base of the mast, just above the tripod a box containing an antenna coupler may be seen (Fig. 8). A second tripod, inverted underneath the buoy, and having lead ballast disks clamped to its apex, may be seen in Fig. 5 and 9. Also seen under the buoy is a copper electrical grounding plate. The buoy was designed to roll not greater than 30 degrees in state 5 seas so as to preclude antenna dropout. Visual observations during the implantments verify this stability was attainable even when the elastic tether was not attached.

Electrical Umbilical and Tether Assembly for the Surface Buoy

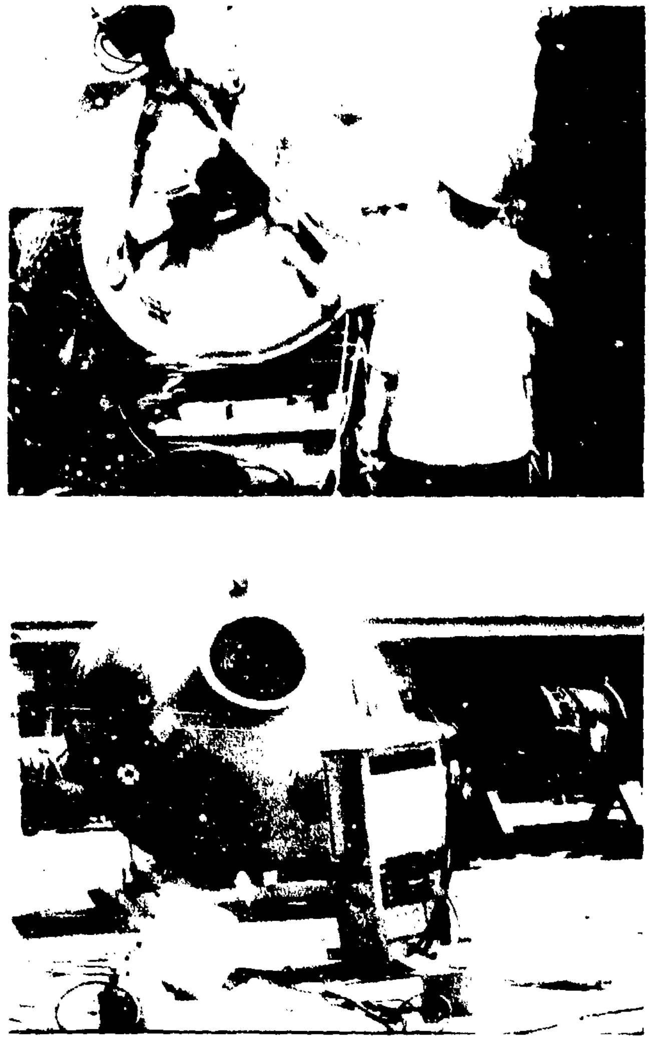
(U) To moor the surface telemetry buoy to the subsurface float and to provide an electrical umbilical between the two, the configuration shown in Fig. 9 was used. This system consisted of five parallel strands of solid 1-inch-diameter natural rubber around which was spiraled an electrical umbilical. The system was designed to provide a taut tether for the surface-following telemetry buoy in the roughest of seas. Initially the umbilical would be pulled down to 200 percent of its original length of 35 feet. Its maximum stretched length would appear as shown in Fig. 9 bottom.

(U) Of the problems involved in fabricating an elastic tether, two caused concern to the project. First, no fishbite protection was provided for the elastic tether. Second, in an elastic tether such as this, chafing may occur as a result of the expansion and contraction of the tether. The positions of the umbilical clamps as well as the eye splices were of concern to the project but appeared satisfactory.

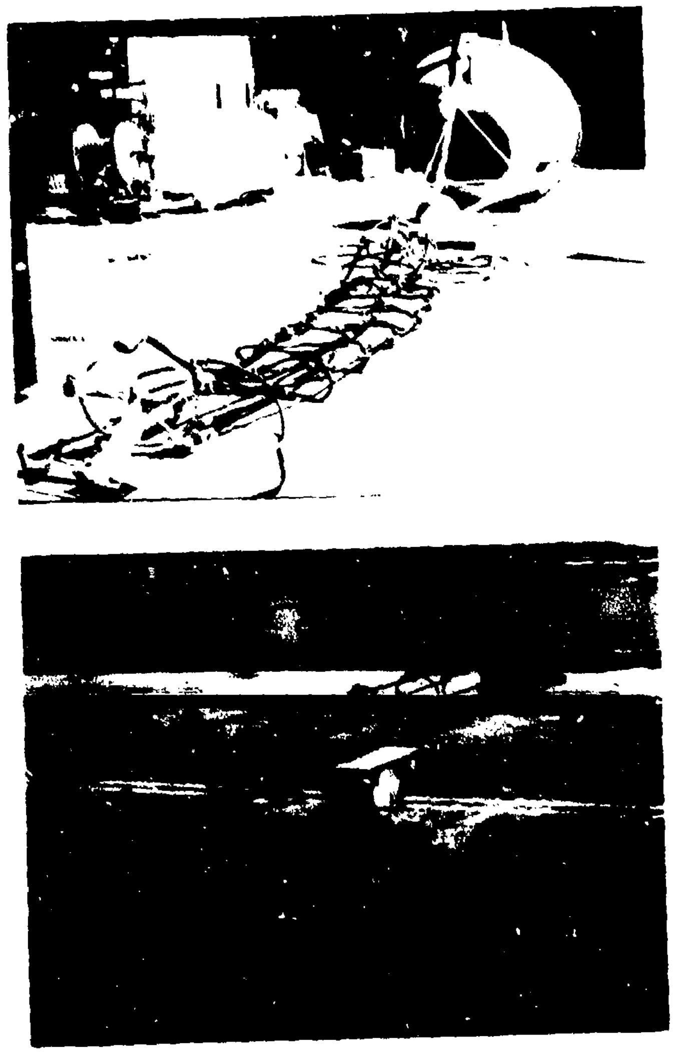
(U) The electrical umbilical around the tether contained a 10-gage copper core and dielectric insulation similar to the legs of Sea Spider. The armor however was very flexible and constructed solely to prevent damage to the electrical conductors; it would not receive any tensile load from the surface buoy. Because of the electrical noise and resistance which might have occurred by using slip rings at the surface or subsurface buoy, fixed electrical terminations were required. Test results demonstrated that a symmetrical taut tether such as this would not twist and hockle.

Array Cable

(U) The electromechanical cable used on the three legs of Pacific Sea Spider was a standard double-armored single-coaxial cable designed and wound by the Rochester



(U) Fig. 8 — Surface telemetry buoy. The upper photo shows the tripod mast support, radar reflector, and antenna tuner box. The lower photo shows the transmitter canister in the foreground.



(U) Fig. 9 — Umbilical and tether assembly when slack and when stretched

Corporation and marketed under stock number 20675. The electrical characteristics were in essence a 10-gage copper center conductor of seven twisted wires and a woven-copper return shield. The dielectric material was high-molecular-weight polyethylene. Corrosion resistance was provided by electroplating the individual armor wires with the maximum thickness of zinc commensurate with its ability to resist cracking during the winding and prestressing operation.

(U) Whereas electrical power limitations required only a 10-gage copper conductor, the hydromechanical requirements conflicted in that by using usual marine-wire-rope safety factors for standing rigging, the moor virtually would have been impossible to deploy. Its necessarily massive weight and large size together with the large subsurface buoy and anchors would have been excessively difficult to cope with, and the attendant hydrodynamic drag would have precluded its meeting the stringent motion specifications. Instead it was necessary to allow static design stresses of about almost 1/2 the breaking strength for the available armoring material, which was 250,000-psi steel. The cable exhibited an effective modulus of elasticity of 13.0×10^6 psi, and even though the cable was very stiff, the legs would have stretched about 140 feet under the static load of the subsurface buoy. Constructional stretch was another variable; that was reduced at the factory by passing the rope over prestressing sheaves to about 1/3 the ultimate strength.

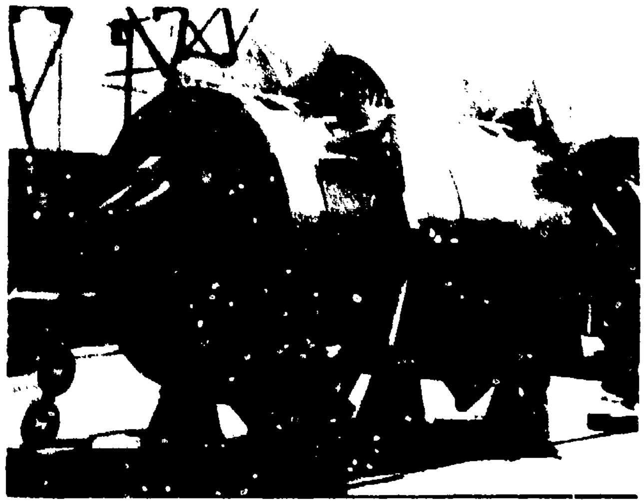
(U) It was necessary to verify the effective cable modulus to assure compliance with the motion specifications of the moor and to precut its legs so that upon elastic deformation in the implanted conditions the subsurface float would remain within the critical depth range of 100 to 125 feet.

Anchors

(U) The three anchors for the legs of Pacific Sea Spider were of the clump or dead-weight type (Fig. 10) Each anchor was composed of 11 cast-iron disks 40 inches in diameter and was 6 feet long. The disks were held together by a central longitudinal tie rod 5 inches in diameter and by three 1-inch-diameter longitudinal rods equally spaced around the periphery of the disks.

(U) Also positioned around the periphery of each anchor at both ends, were 12 flukes which projected outward about 8 inches. These flukes or drag skirts were directional in that they were welded at a 45-degree elevation angle. On each end of the anchor was a shackle, one for attaching the array leg cable and the other for bending on the independent crown line used to lower the anchor. Though the anchors were massive, their heavy weight assisted in their implantment by means of the crown lines.

(U) Bottom-core samples at the implantment site were taken by Hawaii Institute of Geophysics. These samples revealed a mud bottom several feet thick. Assuming a friction/shear coefficient of 1 for the anchors, they should not have dragged when subjected to currents as severe as the design profile.



(U) Fig. 10 — Anchor for one of the three legs

Mechanical Terminations

(U) Pacific Sea Spider required on its three legs about 66 mechanical terminations, all of which were critical to the integrity of the moor. Since the moor was to be highly loaded, the terminations were required to preserve the full strength of the cable.

(U) Conflicting reports concerning the quality of epoxy and woods-metal poured sockets indicated less than full confidence in their ultimate strengths. Mechanical sockets which gripped the individual wires in the armor seemed no better if as good. The performance of the poured and mechanical terminations was limited and related to such variables as quality of workmanship, shelf time of epoxy, and temperature of pour.

(U) A mechanical termination was chosen which was simple to assemble and which was reliable to the full strength of the cable. These terminations manufactured by Preformed Line Products Company, and called Dynagrips, had been designed origin[illegible] for overhead power lines. In essence these terminations (Fig. 11) grasped the outer armor of the cable over a 6 feet length so as to provide bending strain relief as well as a firm grasp. Of importance in assuring integrity of the termination is the proper sizing of the several internal parts of the assembly.

(U) Tests were run at the factory to demonstrate holding power, effect of cable twist on holding power, and the mechanism for cable failure when pulled beyond its tensile capacity. Even though these tests verified the high quality of the design, the project still prescribed that all assembled array-cable terminations would be pulled to about 2/3 the ultimate strength. In this process (Fig. 12) the cable is grasped with a preformed grip or stopper while the bitter and socket is pinned. Like the splice rods in the Preformed Dynagrip, the Preformed cable grips or stoppers are wound around the cable and distribute their compressive loading evenly and over a long enough length so that no damage occurs to the dielectric or electrical parts of the cable.

(U) Fig. 11 — Mechanical termination on the array cable. The preformed wrap extends 6 feet to the left. A pair of terminations held in a housing are used when a T splice is made.

(U) Fig. 12 — Mechanical termination during assembly and test

Sensor Underwater Electrical Terminations

(U) It had not been demonstrated to project personnel that underwater electrical connectors had reached a state of design proficiency which would permit their usage in long-life, continually deflecting cable systems using polyethylene dielectric material. Soldered terminations overmolded with polyethylene were used to assure proper watertight bonding with the sensors and electronics packages permanently connected to the cable system. A winch, cable-reel, and overboarding configuration were designed to enable each leg of the moor to be assembled, molded, tested ashore, and deployed at sea as a prefabricated integral unit (Figs. 13a and 13b).

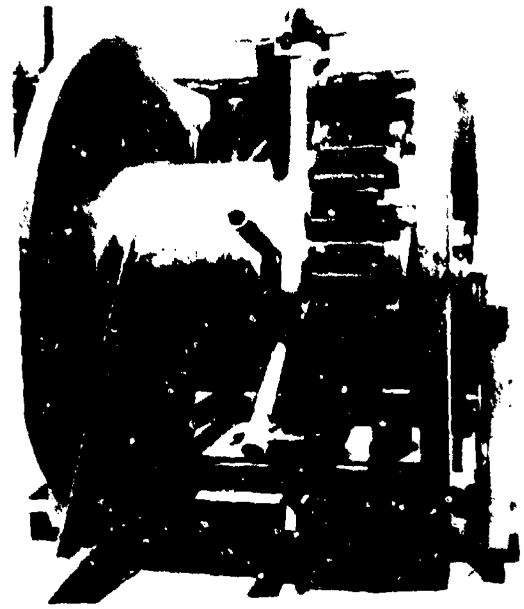
(U) Figure 14 shows a typical hydrophone and electronic package spliced to the array cable. The splices were molded in two stages, the first being a mold over the copper center core. In the Second stage the basketwoven shields were drawn concentrically over the molded section, soldered, and overmolded. The mold plates were of plexiglass and were not heated or cooled; therefore it was difficult to obtain proper bonding at their extremities. In addition the overmolding of the shield tended to melt the inner molding, and the pressure required to force the molten polyethylene into the mold tended to offset the electrical wires so that insulation became thinner than desired in some places. Because of this problem each molded splice required an x-ray examination in addition to normal electrical and visual inspection.

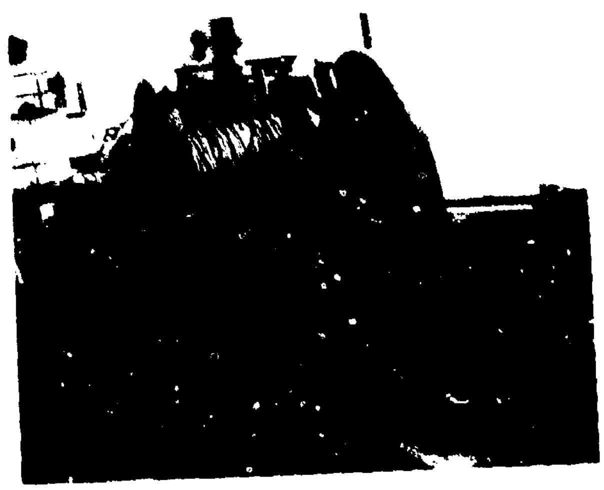
(U) In projects which followed Pacific Sea Spider the molded splice technique was greatly improved (Fig. 15). There no attempt was made to maintain a concentric copper shield over the center conductor, but instead solid single wires bridged the splice. In addition the temperature of the molding operation was controlled by carefully heating and cooling the mold during the pour and cure operations respectively. Because of the rigidity of the wires their spacial relationship was easily maintained when the plastic was molten, and no difficulties existed inserting an electrical fuse inside the mold. All molded splices were more easily visually inspected and x-rayed in the improved technique because of reverting to single copper conductors instead of bridging the splice with coaxial conductors. No electrical degradation of consequence occurred by simplifying the procedure.

Leg-Cable Buoyancy

(U) To provide the necessary long-period motion stability for the moor, it was required that in addition to the 26,000-pound-buoyancy subsurface float, the legs be made neutrally buoyant. To accomplish this weightlessness, 16-inch-diameter glass floats which provided 48 pounds net buoyancy were used to a depth of 1600 feet at intervals of 86 feet. Below that depth, where the design current profile was not severe, 10-inch glass spheres having 12 pounds buoyancy were affixed at intervals of about 20 feet. Where heavy masses were placed on the cables, such as hydrophone assemblies, additional spheres were necessary. The larger spheres, which were more difficult to handle than the smaller spheres, were needed to lump the buoyancy for purposes of drag reduction. Since buoyancy increases as the cube of the diameter whereas drag increases only as the square, drag could be significantly reduced by lumped buoyancy. Other factors were traded off to reach such a decision: catenary between floats, deployment problems, mass loading of the float on the cable, and cost.

(U) Fig. 13a — Empty cable reel. The rubber-lined receptacles on the right are for hydrophones

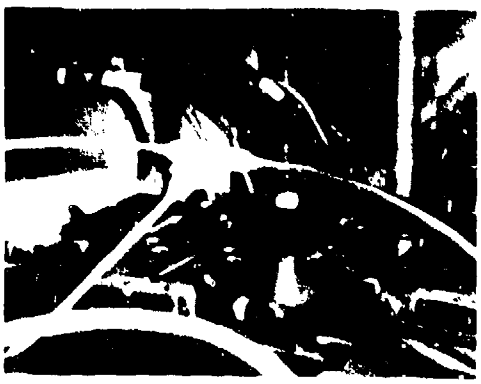




(U) Fig. 13b — Cable reel during deployment. On the right is a large acoustic projector to be positioned above an anchor.

(U) Fig. 14 — Pair of mechanical cable terminations (held by man at left), a hydrophone in a vibration-isolation cage, and (upper left) an electronics package

(a) Splice (with fuse) before molding



(b) Splice after molding

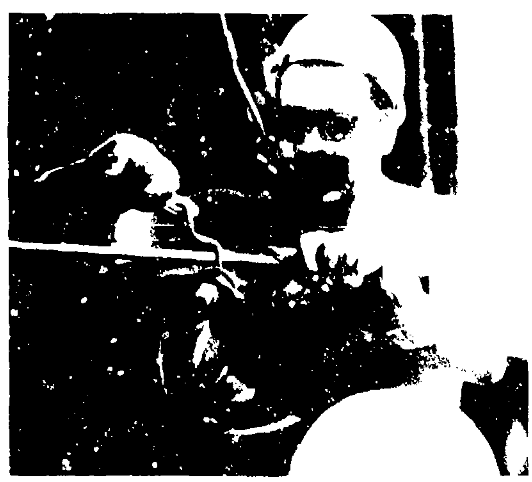
(U) Fig. 15 - Improved mold splicing technique

(U) Fig. 16 — Polyethylene-jacketed buoyancy elements in comparison to a yardstick. A wire-rope tether and nylon cable grip is attached to the 16-inch sphere. The two 10-inch spheres are identical.

(U) Fig. 17 — Three-man crew attaching a 16-inch sphere to the array cable with a pop rivet gun

(U) The 16-inch spheres were housed in polyethylene teardrop-shaped enclosures (Fig. 16) with fins to orient them into the current. Tests indicated that this substantially decreased their hydrodynamic drag coefficient. To provide free orientation without fouling the array cable, it was necessary to provide a flexible steel pendant between these spheres and the cable. On the cable was a nylon-strap thrust collar which was free to rotate to relieve any twists which occurred during array deployment. This 16-inch-sphere attachment could be quickly riveted to the cable (Fig. 17), but the attachment proved unsatisfactory during implantment, because wave action and the motion of the moor near the surface twisted the spheres and their 1/8-inch-diameter wire-rope pendants to the point where many spheres broke loose.

(U) On the other hand the 10-inch spheres, which were also encased in polyethylene housings, though spherical, were attached directly to the array cable by preformed cable grips (Fig. 18). Virtually no difficulties arose upon their deployment. The use of preformed cable grips for holding glass floats to the array cable afforded an excellent means of attachment for the spheres but consumed excessive manpower. At cable deployment rates of about 1 knot, which appeared to be the optimum speed, it was necessary to attach five spheres to the cable each minute. (The cable was color coded where spheres were to be attached.) For the normal crew of three this rate was too high for continued operation; thus a four- or five-man team was required. The procedure used in attaching the spheres was for a man in the ship's hold to pass the spheres up to the main deck, where a second crewman would pass them to a third, who would position the grip on the leg cable as it was being deployed between the line tensioning winch and the stern roller. Opposite the positioning man a fourth crewman twisted both ends of the preformed wrap, and a fifth man with marlin spike or screwdriver tucked both the ends of the wrap around the leg cable, completing the operation.



(U) Fig. 18 — Method of attaching the 10-inch spheres to the array cable

(U) The spheres were supplied by Corning Glass Works and were designed not to implode below 15,000 psig; no evidence exists that any floats did implode during the deployment operation. A random sample of 90 of the 10-inch spheres were tested by the manufacturer to 10,000 psig without failure; even spalling of the seam weld would have constituted such a failure. The 16-inch spheres were not tested, because of their use at relatively shallow depths (above 1600 feet), though some ultimately were used to buoy the heavy hydrophone mountings even at deeper depths.

Vibration-Isolation Mountings

(U) Because of the high dynamic range required of the acoustic receiving system of the moor it was necessary to isolate the hydrophones from the leg cables, which were likely to generate unwanted noise, mostly from strumming and secondly from the rubbing of appendages on them. It was decided that the originally proposed elastic-shock-cord tether would be insufficient vibration isolation and that a neutrally buoyant hydrophone assembly mounted on very soft springs would be needed. Figure 14 shows the design of the cagelike assembly which ultimately housed the large 35-pound (dry weight) hydrophones, and Fig. 19 shows the testing of the cages.

(U) Fig. 19 – Hydrophone vibration-isolation cage being tested for neutral buoyancy and vibration isolation

(U) The assembly consisted mainly of an outer cage which was clamped to the array cable and an inner cage which contained the hydrophone. The inner cage was made neutrally buoyant by a 16-inch glass float at each end. Soft springs having natural frequencies of about 1 hertz, and coated with plastic to prevent their corrosion and consequent detuning, separated the two cages. The cage assemblies were 26 inches in diameter and 8 feet long. Their weight in air was about 350 pounds, though they were lightly constructed.

(U) It was necessary to manipulate them by crane between their stowage bins on deck to the location abaft the tensioning winch where they were clamped to the leg cable. To clamp the cages to the array cable it was necessary to halt payout and stopoff the cable, the latter as a safety precaution. The cage was set on a wooden cradle mounted on skids (Fig. 14). After the outer cage was clamped to the cable, the hydrophone was clamped in the inner cage and the electrical leads clamped as shown to prevent their

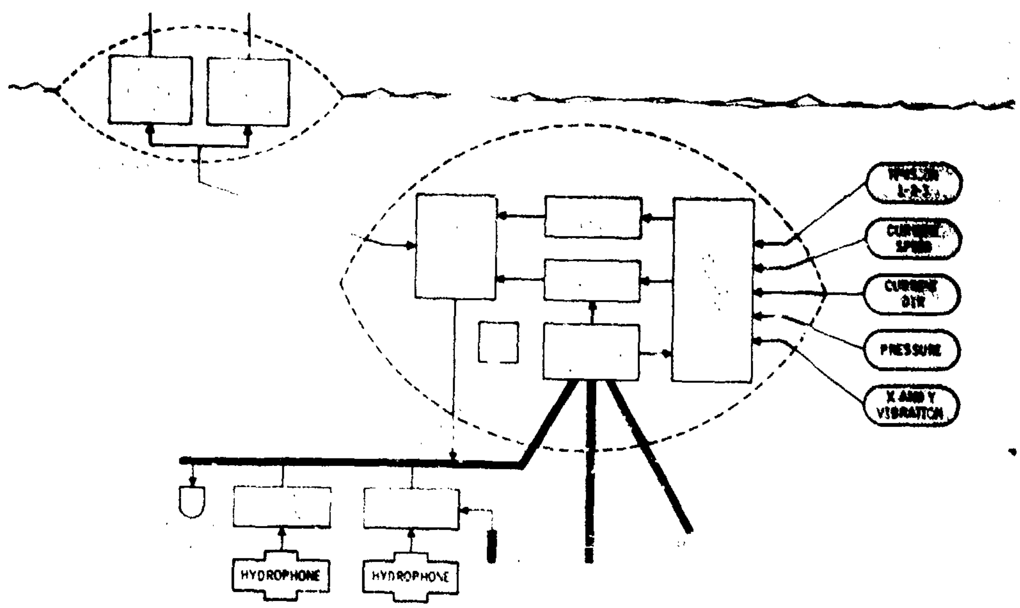
snagging and chafing during and after deployment. Lastly the hydrophone electronic package was clamped to the cable, the cable stopper removed, and the deployment continued. Assembly of a cage required about 1 hour.

(U) The cage assemblies were slid along the deck on their skids and over the stern roller (Fig. 20) into the water, the skids being retrieved by pendants attached to them. Though the skids served as a cradle for assembling the hydrophone electronic cage during deployment and for deploying that assembly over the stern without damage, more expeditious methods are evident. For example a boom or overhead gantry with quick release would have provided a smoother deployment operation.

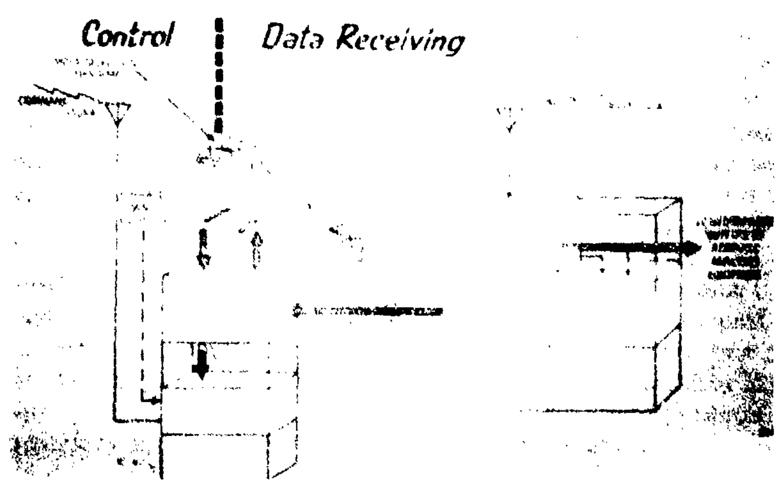
(U) Fig. 20 — Goal-post-like stem chock with a removable bar at top and a roller at the bottom for deploying the array cable from the stern

ELECTRONIC SUBSYSTEM

(U) Figure 21a shows the Sea Spider in-water instrumentation system, and Fig. 21b shows the shipboard system. The in-water system consisted of three instrumented cables terminated electrically in the subsurface buoy by signal-conditioning and control circuits and the main power supply for the system. An electromechanical cable conducted the signals to the surface buoy, which contained a VHF transmitter for telemetering data to a nearby monitoring vessel and an HF transmitter for telemetering a limited amount of oceanographic and engineering data to a shore station. The HF transmitter also sent out a special alarm code if the cable between the subsurface and surface buoys shorted or parted. The surface buoy also contained a command receiver to receive the command-and-control signals emitted by the monitoring ship. The shipboard system received and monitored the signals from the in-water system. These acoustic and engineering-data signals were demodulated to provide audio signals to analysis equipment. Engineering data were fed to a small general-purpose computer which was programmed to convert the inputs to engineering units and display the results on a teletypewriter. The computer also was programmed to encode commands from the teletypewriter for transmission to the surface buoy, where they were received and routed to decoding equipment.



(a) In-water electronic system



(b) Shipboard receiving and control system

(U) Fig. 21 -- Sea Spider instrumentation systems

Power

(U) Primary power for the Sea Spider electronics was derived from the three radioisotope thermoelectric generators (RTGs) with a combined continuous power output capability of 75 watts. A dc-dc converter was used to increase the low output voltage (7.5 volts) of the RTGs to those voltages required by the electronics. Figure 22 shows power distribution for the system. In general, RTG power was used to maintain a charge on storage batteries which in turn provided regulated voltages to the electronics in each leg, the surface buoy, and the subsurface buoy. The surface-buoy batteries also permitted continued operation of the HF transmitter and navigation light if the buoy broke loose from the subsurface float.

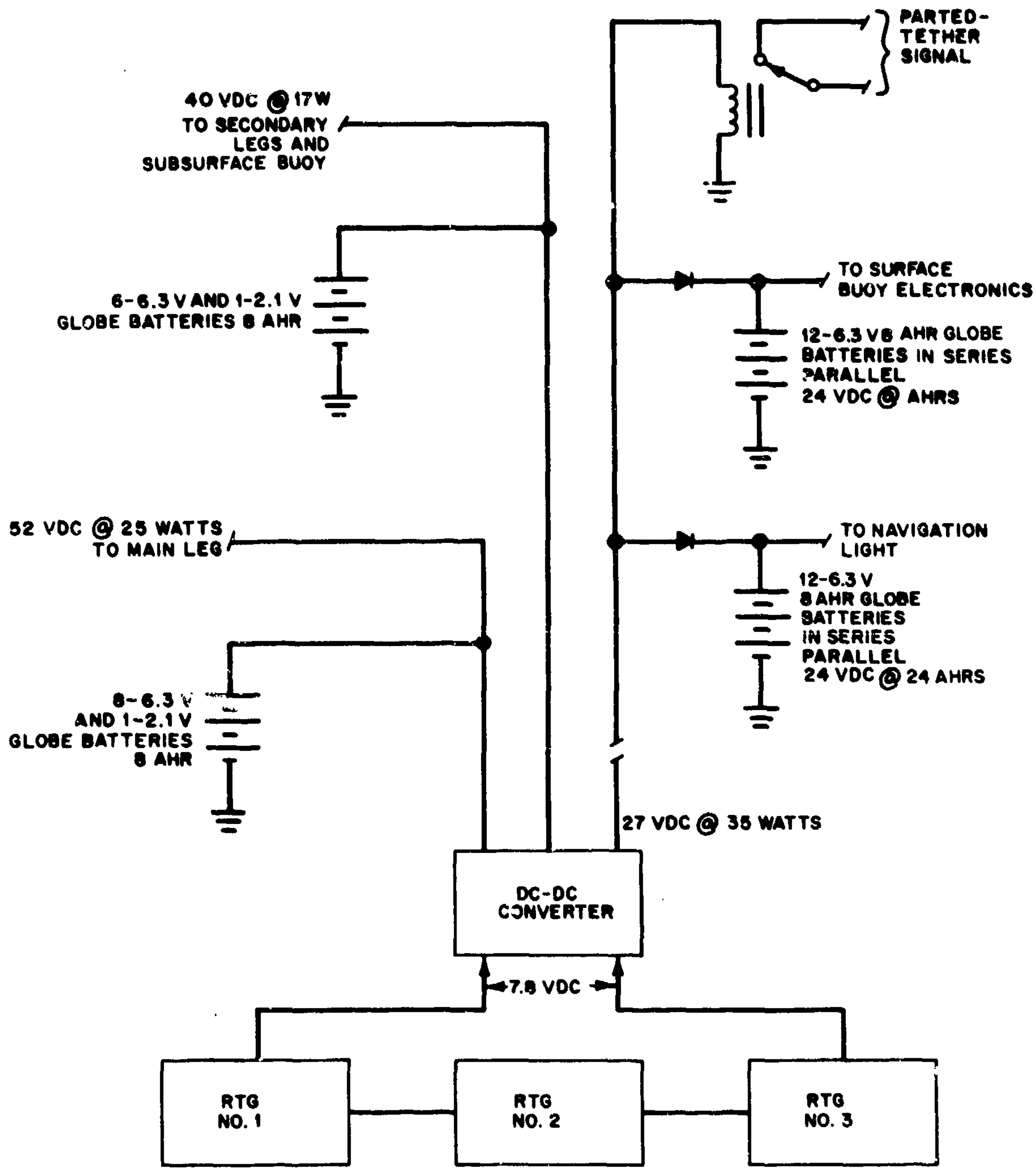
Instrumentation Overview

(U) Sea Spider instrumentation consisted of 30 hydrophones, three acoustic projectors, 14 oceanographic sensors (current speed, current direction, and temperature), six engineering sensors (vibration, tension, depth, and electrical monitors), and three explosive cutters (one for each leg) to release the system from its moor if desired (Fig. 23). When the sensors were turned on and were operating, their outputs modulated individual voltage-controlled oscillators which differed from one another in their center frequency. These modulated signals were then multiplexed onto the coaxial leg cable and telemetered to the subsurface buoy. In the buoy each signal was translated to one of 15 preselected frequencies spaced 60 kHz apart between 10.00 MHz and 10.84 MHz. These signals were then translated to individual VHF carrier frequencies between 162.25 and 173.50 MHz and transmitted from the surface buoy to the data-processing ship nearby. The output signals from the 12 hydrophones and up to 18 oceanographic and engineering sensors could be transmitted simultaneously by means of 15 VHF carrier frequencies in this manner. The sensors transmitting data were chosen in advance by coded command signals from the data-processing vessel. These command signals turned on the desired sensors and concurrently turned off power to the undesired sensors. Other coded command signals activated the acoustic projectors and the explosive cutters.

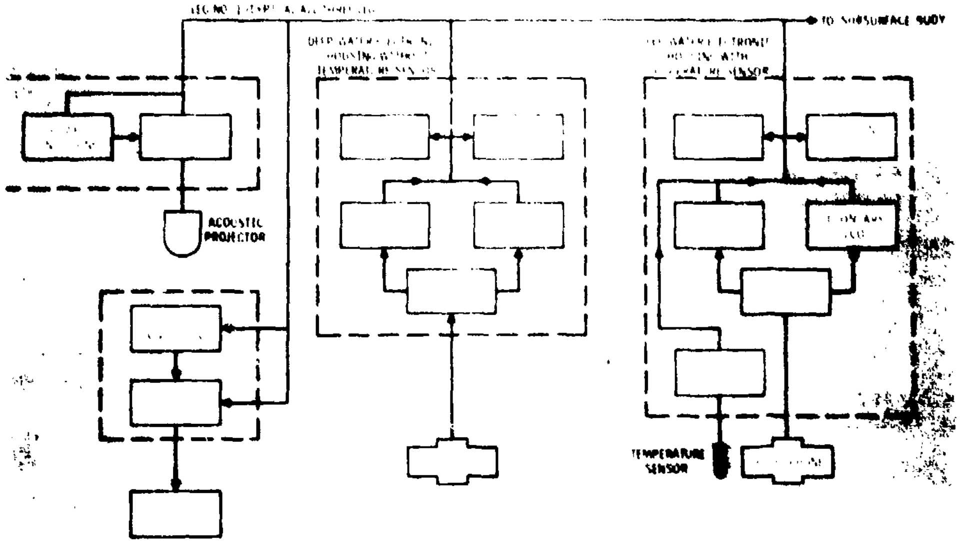
(U) Tables 1 and 2 list the voltage-controlled-oscillator (VCO) and bridge-controlled-oscillator (BCO) frequencies for each sensor. Table 1 identifies the VCO frequency for each hydrophone and the BCO frequency for the temperature sensor at specific hydrophone positions. Table 2 additionally indicates six preselectable operating modes or groupings of sensors which could operate simultaneously. These frequencies and groupings were selected to minimize intermodulation products which could increase system noise.

Hydrophone and Temperature Electronics

(U) The hydrophones used in Sea Spider were Western Electric Company type GF44787 lead titanate zirconate acceleration canceling units which had a sensitivity at 100 Hz of −89 dB relative to 1 volt/μbar and generally flat from 10 Hz to above 1000 Hz. The hydrophone circuitry is shown in Fig. 24. An input protector caused the input to short out if levels in excess of 1 volt occurred at the hydrophone output; recovery from



(U) Fig. 22 — Distribution of power from the radioisotope thermoelectric generators (RTGs)



(U) Fig. 23 — Electronic system on a leg cable shown in more detail than in Fig. 21a

(U) Table 1
Hydrophone Voltage-Controlled-Oscillator (VCO) and Temperature-Probe Bridge-Controlled-Oscillator (BCO) Frequency Assignments

Leg 1			Leg 2			Leg 3		
Sensor*	Frequency (kHz)		Sensor*	Frequency (kHz)		Sensor*	Frequency (kHz)	
	Hyd VCO	Temp BCO		Hyd VCO	Temp BCO		Hyd VCO	Temp BCO
A101	100	—	A201	100	—	A301	100	—
A102	160	—	A202	160	—	A302	160	—
A103	280	—	A203	280	—	A303	280	—
A104	340	—	A204	340	1.300	A304	400	—
A105	400	—	A205	400	—	A305	460	—
A106	640	—	A206	640	—	A306	520	0.400
A107	520	1.300	A207	520	1.700	A307	340	0.560
A108	580	1.700	A208	580	2.300	A308	580	0.730
A109	880	—	A209	880	—	A309	640	0.960
A110	460	2.300	A210	460	3.000	A310	880	1.300

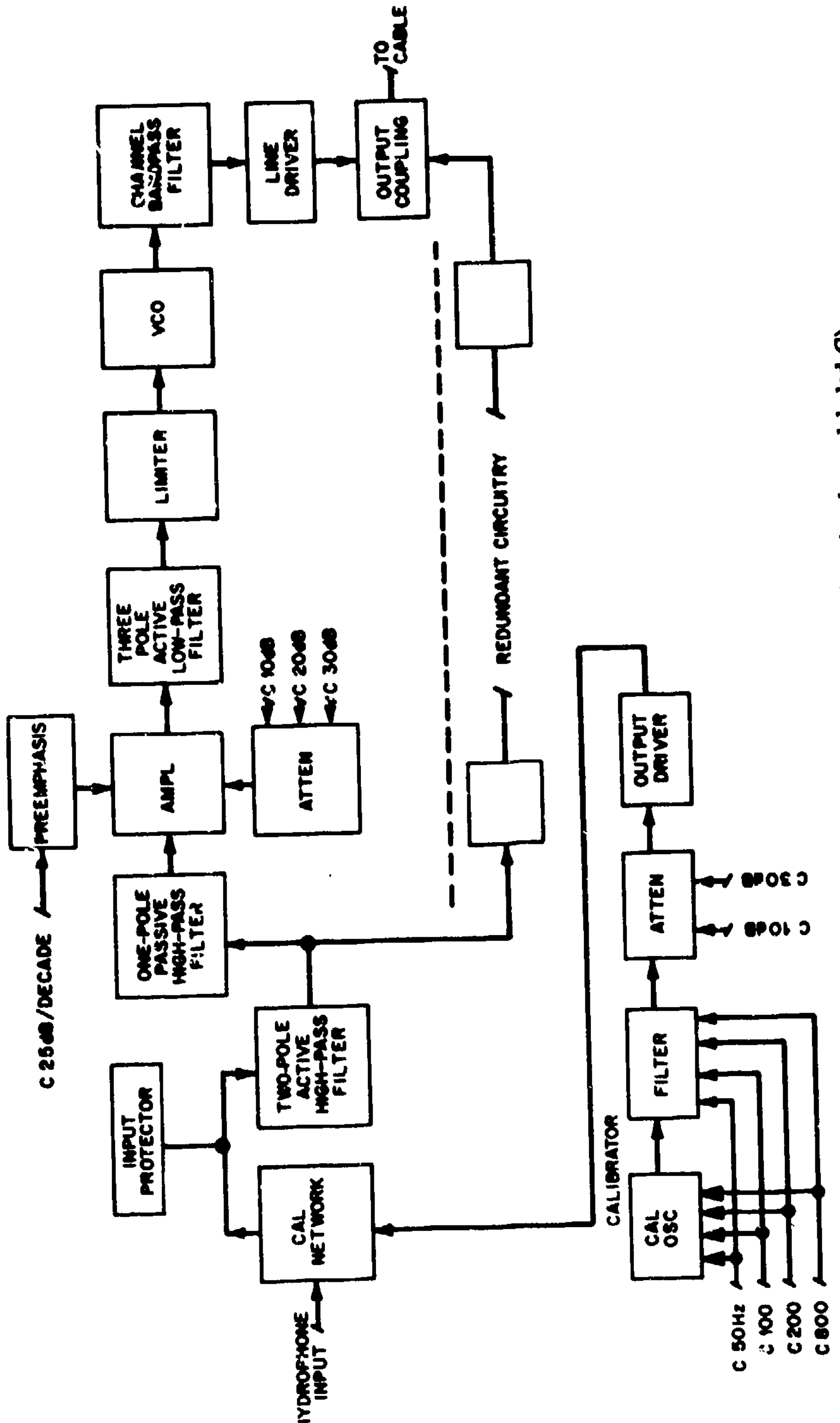
*Numbered from the bottom of the leg to the top.

(U) Table 2
Mode Groupings and Engineering-Sensor Frequency Assignments (T = Temperature, C.S. = Current Speed, C.D. = Current Direction, VIB = Vibration, TEN = Tension)

Subcarrier Channel Number	IRIG Channel		Mode					
	No.	Center Freq. (Hz)	1	2	3	4	5	6
1-12	NA	See Table 1	A101-110, 208,308	A101-110 303,302	A201-210, 303,302	A201-210, 308,107	A301-310, 207,108	103,104, 107,108, 202,203, 207,208, 304,307, 308
13	1	400	—	—	—	—	T-08	—
	2	560	—	—	—	—	T-09	—
	3	730	T-10	—	—	T-10	T-10	T-10
	4	960	—	—	—	—	T-11	—
	5	1300	C.S.	C.S.	C.S.	Misc.	T-12	C.S.
	6	1700	Depth	Depth	Depth	Depth	Depth	Depth
14	5	1300	Misc.	Misc.	T-04	T-04	C.S.	Misc.
	6	1700	—	—	T-05	T-05	T-05	T-05
	7	2300	T-06	C.D.	T-06	T-06	—	T-06
	8	3000	—	—	T-07	T-07	—	—
	9	3900	VIBX	VIBX	VIBX	VIBX	VIBX	VIBX
	10	5400	VIBY	VIBY	VIBY	VIBY	VIBY	VIBY
15	5	1300	T-01	T-01	Misc.	T-01	Misc.	—
	6	1700	T-02	T-02	—	—	T-02	T-02
	7	2300	T-03	C.D.	T-03	C.D.	C.D.	C.D.
	8	3000	TEN1	TEN1	TEN1	TEN1	TEN1	TEN1
	9	3900	TEN2	TEN2	TEN2	TEN2	TEN2	TEN2
	10	5400	TEN3	TEN3	TEN3	TEN3	TEN3	TEN3

this overload condition was to occur in 1 microsecond. A high-pass filter provided roll off below 10 Hz, and the low-pass filter provided roll off above 1 kHz. In addition a limiter was used to prevent overdriving of the voltage-controlled oscillator. The dynamic range was specified at 70 dB (50 to 1000 Hz) with allowable degradation to 50 dB (10 to 50 Hz). Each hydrophone output had a redundant VCO circuit which could be selected by an appropriate command signal. Preemphasis of 10 or 25 dB/decade from 50 to 1000 Hz, and signal attenuation in 10-dB steps was also selectable. Calibration was provided for 50, 100, 200, and 800 Hz at three equivalent input levels.

(U) The temperature sensor range was ±3°C and 0.02°C in resolution. Each temperature probe was adjusted so that its midscale was at the expected ambient temperature at that depth. Each sensor was located inside the electronic pressure case, and its output



(U) Fig. 24 — Hydrophone circuitry (calibration signals are labeled C)

modulated a bridge-controlled oscillator which was coupled to the output in parallel with the hydrophone VCO circuit.

(U) In addition to signal-conditioning electronics, each hydrophone electronic package contained a voltage-regulator circuit and a command decoder. The voltage regulator kept input voltages at +50 volts. The command decoder ensured that selected functions (calibrate, on, off, attenuator setting, etc.) were activated.

Subsurface-Buoy and Surface-Buoy Electronics

(U) In addition to the RTGs the subsurface buoy housed the electronics for translating the sensor VCO signals to the RF carrier frequencies. Each hydrophone signal was initially mixed with a 10-MHz signal to yield sum and difference frequencies and then filtered to eliminate all but the first sum frequency (e.g., 400-kHz VCO frequency plus 10 MHz yields 10.4 MHz). It was then mixed again with a 180-MHz frequency and thereupon filtered to eliminate all but the first difference frequency to yield the carrier frequency. This signal was passed through the coaxial cable to the surface buoy, where it was amplified and transmitted to the monitor ship.

(U) Each engineering and oceanographic sensor signal had a low-frequency carrier (Tables 1 and 2) and occupied a small bandwidth compared to the 60 kHz required for the hydrophone signal. This made it possible to linearly add six of these sensor signals after filtering the outputs of their bridge-controlled oscillators. This combined signal was then treated in the same manner as a hydrophone signal.

(U) The surface buoy contained 15 primary VHF transmitters and 15 alternative units. The transmitter outputs were coupled together to one VHF antenna mounted on a mast on the buoy. The antenna beam pattern was steered horizontally with a total beamwidth of 30 degrees to provide an effective increased power output. A separate VHF antenna was used to receive the command signals from the monitor vessel. These command signals were decoded and transmitted through the coaxial cable to individual code-sensing circuits at each instrument.

(U) The HF transmitter in the surface buoy could be activated to transmit selected oceanographic, engineering, and alarm information to a shore station. The HF signal consisted of 2-minute coded messages in five-level radioteletype at 4 and 16 MHz simultaneously. The transmitter would be turned on whenever the data-monitor ship left the area and thus would permit on-line monitoring of essential information concerning the status of the surface and subsurface buoy. In particular, if the umbilical coaxial cable connecting the subsurface and surface buoys parted, a radio beacon and a navigation light would be activated. The battery power in the surface buoy was sufficient to operate the beacon for 11 days and the flashing navigation light for 30 days. A radar reflector on the mast would also aid in a search for the buoy.

Data-Acquisition System

(U) The data signals were separately received on the monitor ship and demodulated. Twelve hydrophone demodulators and 18 engineering-sensor demodulators were provided for this purpose. The output impedance of the demodulators was low and could be connected to any general-purpose instrumentation arrangement. In the first planned use of Sea Spider these outputs were to be connected to a shipboard Univac 1230 computer through analog filters and a multiverter. In parallel with this system it was planned to record the signals on magnetic tape and monitor them on graphic recorders. In addition the engineering-sensor signals were input to a HP 2115A computer, where they were converted to engineering units and displayed on the teletypewriter.

Command and Control

(U) The command-and-control unit on the ship was used to program a control signal consisting of CW tones. To select a specific function on the array, two address tones and two command tones were necessary. The address tones determined which array unit was to be changed, and the command tones determined what change was to be made. These tones were in the frequency range 8 to 14 kHz, and each set of tone pairs was selected by means of a digital 12-bit word (Table 3). Bits (tones) were set and commands executed by means of switches accessible on the front panel of the command-and-control unit. This unit was also interfaced with an HP 2115A general-purpose computer which was programmed to step automatically through an entire sequence of commands on instruction from the teletypewriter. For instance, if mode 1 (Table 2) was selected on the teletypewriter, the computer would go through a sequence of turning off all sensors not contained in the mode 1 list and turning on all sensors on that list which were off. These tone signals were transmitted to the surface buoy on a VHF carrier frequency of 169.00 kHz.

Performance of the Acoustic Sensors

(U) Following are the results of the more important tests:

(U) • Dynamic range of the acoustic sensors. This was measured by replacing each hydrophone with an equivalent capacitor and shunt feeding this capacitor from a signal generator. Output was measured at the receiver discriminator. The dynamic range figures are the difference between maximum undistorted output and the system noise for zero output. The average value obtained during the tests at the assembly area at Santa Barbara was 60 dB. Although this value was 10 dB lower than the specification, excessive radio noise in the vicinity of the Santa Barbara airport, which was adjacent to the test site, prevented accurate measurements. Later, during tests at Pearl Harbor Naval Ship Yard, 65 dB dynamic range was obtained when tested under conditions of less radio noise. It is considered possible that the designed 70 dB was met at the implantment site.

(U) • Crosstalk. This was measured by sequentially fully saturating each channel of the system and measuring coherent noise in each of the other channels. The required value was −70 dB. During the tests at Santa Barbara the average value obtained for all

(U) Table 3
Hydrophone Electronics Command Word

Bit Status	Command											
	Bit. No. 11	Bit. No. 10	Bit. No. 9	Bit. No. 8	Bit. No. 7	Bit. No. 6	Bit. No. 5	Bit. No. 4	Bit. No. 3	Bit. No. 2	Bit. No. 1	Bit. No. 0
On	Power off	"B" VCO Select	Short on	Calibrate power on	Calibrate frequency 00 = 800 Hz 01 = 200 Hz 10 = 100 Hz 11 = 50 Hz		Preamplifier gain 00 = normal 01 = −10 dB 10 = −20 dB 11 = −30 dB		Calibrate level 00 = −59 dB 01 = −79 dB 10 = −89 dB 11 = Not used		Preemphasis high	Shunt on
Off	Power on	"A" VCO Select	Short off	Calibrate power off							Preemphasis low	Shunt off

hydrophones was −60 dB. (This value was higher than the true value because of radio noise.)

(U) • Frequency response. The observed performance of all channels, though slightly exceeding the specified 5 dB, was considered adequate.

(U) • Preemphasis. Good agreement was obtained between observed readings and specifications.

(U) • Phase-shift between channels. Because of project scheduling limitations, only five pairs of channels were checked. In each case these were within 1 degree at 10 Hz and 20 degrees at 1000 Hz, thus meeting the specifications.

(U) • Linearity of each channel. All channels tested were considered adequate.

(U) • Recovery of a channel after overload. The specification called for a maximum recovery time of 1.0 millisecond from saturation overload. This value was achieved for a saturation level of 3 dB above overload condition. Even for 23 dB overload the recovery time was only 4 milliseconds.

(U) • Calibration oscillator levels. In all cases good agreement was obtained between the observed readings and the specifications.

(U) • Hydrophone sensitivity. Calibration of sensitivity and admittance were carried out at the NRL/USRD facility at Orlando, Florida, and free-field calibrations were carried out at USRD, Leesburg, Florida. All units were within the specification.

(U) • VHF telemetry and command range. The specifications called for a range of not less than 5 miles or greater than 7 miles. It is probable that this would have been achieved had the moor been successful. Originally a common antenna was used for both the telemetry and command links. The design signal strength required at the receiver input was 20 microvolts; in tests conducted from the Santa Barbara airport to the USNS *Sands* this could not be obtained at ranges exceeding 3 miles. Later, separate antennas were fitted for both the telemetry and command links, and a reassessment showed that a signal strength of 10 microvolts was adequate. These figures were obtained at 5 miles in a test from the Santa Barbara airport to the *Rigbuilder*.

(U) • HF long-distance telemetry link. This system proved adequate for ranges greatly in excess of the required 400 miles. Data sampling at the buoy and reception and printout at the remote station proved satisfactory.

(U) • Command-and-control system. As Sea Spider grew in complexity from relatively simple beginnings, command of the various hydrophone conditions and modes became a major design problem. This was overcome by using a small general-purpose data processor to program and control the system. This same unit also was used to convert raw engineering data into engineering units. The system proved quite complex and used

most of the 4096 words of the magnetic core memory of the 16-bit machine. Despite its complexity the system was operated for hundreds of hours during the test period and proved simple to operate and reliable.

Performance of the Temperature Sensors

(U) The specification called for 12 temperature sensors at selected hydrophone positions; each of these was to be capable of measuring with an accuracy of 0.02°C. The system adopted was capable of this precision, and those probes which were operating during implantment achieved this accuracy. The temperature system used the same VHF link as the acoustic system, and satisfactory transmission of data was obtained at ranges equal to those quoted for the acoustic signals. Readout aboard the research vessel, on the strip-chart recorder, punched paper tape, and by visual means, were all satisfactory. In the HF mode, scanning and programming methods used proved adequate and printout at the remote station was satisfactory.

Performance of the Engineering Sensors

(U) Sea Spider was designed essentially as an acoustic tool; therefore, almost all of the telemetry capacity was required by the scientists to be devoted to acoustic data channels. A small number of engineering sensors were fitted to record the dynamic properties of the moor and to provide minimum data for the design of subsequent moors. Indications, were that the performance would have been satisfactory had the moor been successful.

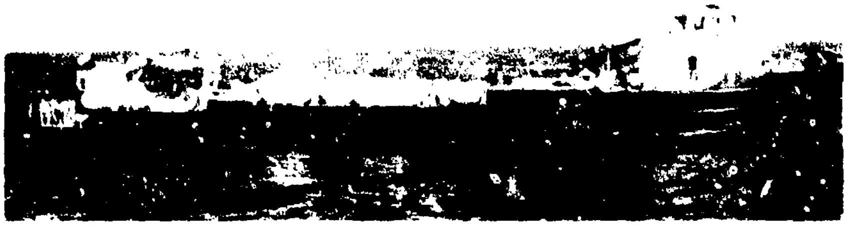
IMPLANTMENT SUBSYSTEM

(U) The implantment subsystem consists of three main categories: ships and personnel, handling equipment, and the implantment operation.

Ships and Personnel

(U) From the beginning of the project it was concluded that at least two ships would be necessary to implant the moor within the tolerances required by LRAPP scientists — an implantment work vessel and a navigation ship. For the first implantment attempt these two ships were supplemented with a third ship for berthing relief personnel and for performing picket duty by warning other ships from steaming across the implantment site. During the second implantment attempt, six weeks after the first, a fourth ship was used to assist in navigation duties.

(U) The work vessel, MV *Rigbuilder*, a 168-foot offshore-oil-rig supply boat, carried almost all of the mooring and auxiliary equipment (Fig. 25). This hardware weighed about 420 long tons, 80 tons of which were the moor proper.



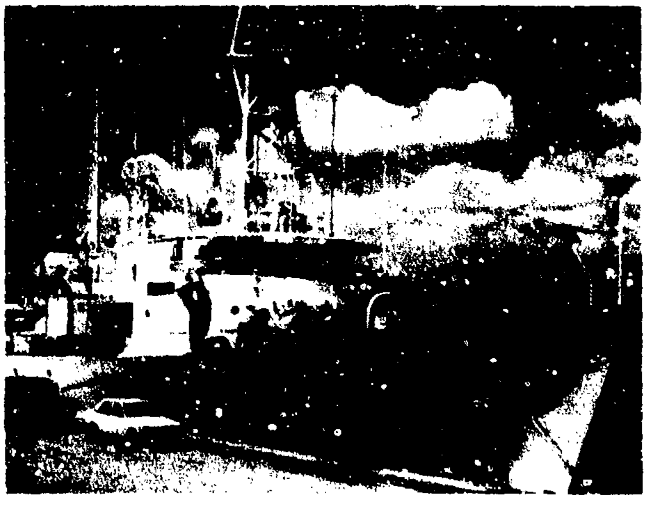
(U) Fig. 25 — The work vessel, MV *Rigbuilder*, fully loaded with about 420 tons of equipment and supplies and on station ready to begin deployment

(U) The *Rigbuilder's* main plant consisted of two 2000-shp diesel engines driving twin screws; she could sustain a speed of 10 knots and had a cruising range of 4000 miles at that speed. Having a broad beam, twin screws, and a bow thrust propeller mounted in a transverse tunnel through her forefoot, she proved highly maneuverable for such difficult positioning as the backing and filling necessary when connecting leg cables to the subsurface buoy at moor center.

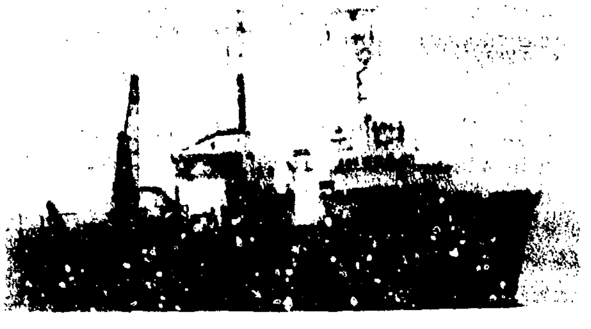
(U) The ship's beam of 36 feet which was carried along the length of her 80-foot-long cargo deck was ideal for stowing and handling equipment. Her broad fantail, which was of low freeboard, allowed ease of working over the stern and of placing the heavy-lift converted backhoe crane near the transom.

(U) The *Rigbuilder* was an excellent ship for the type of implantment, though cramped for stowage and berthing space for this project. To offset these minimal facilities, certain equipment was carried aboard the primary navigation and signal monitoring vessel, USNS *Sands* (AGOR-6). For example it was necessary to mount the diver decompression chamber on her foredeck because of space limitations. The *Sands* (Fig. 26) was an oceanographic research vessel assigned to the Naval Underwater Systems Center, New London Laboratory, which was then known as the Naval Underwater Sound Laboratory. The *Sands* had installed in her hull suitable sonar equipment for acoustic ocean-bottom navigation from transponders and a satellite navigator for surface navigation. In her laboratory Sea Spider electronic receiving and computing equipment was installed to monitor the array. Upon array deployment she was to remain as the monitor ship for 2 weeks, after which she would have been relieved by another vessel.

(U) The USS *Marysville* (EPCR-852) provided berthing services for various *Rigbuilder*-deck-force relief personnel and certain others such as isotope-generator inspectors who could not be berthed on either of the other ships. The *Marysville* served as a radio communications ship to Hawaii and as a patrol vessel.



(U) Fig. 26 — The USNS *Sands*, the navigation and signal-monitoring vessel. The diver compression chamber is just forward of the deckhouse.



(U) Fig. 27 — Research vessel *Robert D. Conrad*, which assisted during the second implantment attempt

(U) During the second implantment attempt the research vessel *Conrad* (Fig. 27) assigned by the Navy to Columbia University, assisted in providing continuous surface navigation data between the marker buoy at moor center and the *Rigbuilder*. In addition, she also berthed overflow personnel and provided deck-force assistance during deployment.

(U) Means for the transfer of personnel between ships during the first attempt consisted of a 20-foot V-bottom inboard motor boat aboard the *Rigbuilder*, a motor whaleboat aboard the *Marysville*, and a 16-foot outboard skiff (Boston whaler) aboard the *Sands*. Two motorized rubber boats (a 12-foot Zodiac and a 12-foot Z-bird) were also carried by the *Sands*. These rubber boats proved valuable during rough seas when boarding offered the hazard of hands or feet being caught between ship and boat.

(U) The implantment of Pacific Sea Spider was predicated on round-the-clock operation once it was begun. During the first attempt the workload was found to be more tiring than previous implantment exercises led one to believe, and during that attempt the exercise was halted temporarily because of crew exhaustion. During the second attempt port and starboard deck work sections were established which would have been able to persist under the difficult conditions until the completion of the implantment. The *Rigbuilder's* decks were well lighted, and operations at night offered no special limitations. A safety officer was stationed in the deployment area, and during the second attempt personnel were required to wear safety helmets. In addition, a medical doctor who was a qualified diver was stationed aboard the *Rigbuilder* in the event of emergencies. No such injuries or diving emergencies occurred.

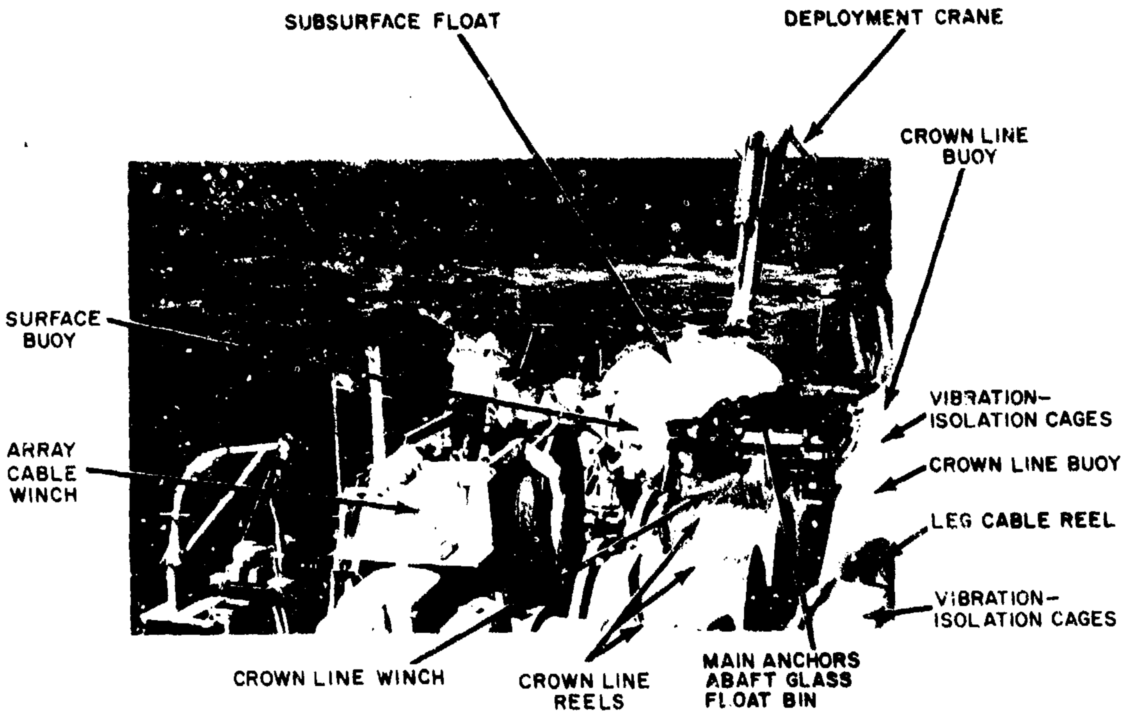
(U) Responsibility for implanting the Pacific Sea Spider belonged to the prime contractor, Interstate Electronics Corporation (IEC), which delegated to their major subcontractor, General Motors, the task of devising the implantment procedure and providing the vessel and marine personnel to accomplish the deployment operation. Personnel from IEC limited their physical tasks on board the *Rigbuilder* to the assembly of equipment (glass floats, hydrophones and sensors) onto the leg cables. Other IEC personnel were stationed aboard the assist ship *Sands* to check out the receiving and command electronics and to monitor the moor during implantment. In addition IEC divers performed tasks related to the inspection and handling of electrical hardware on the deployed buoys, whereas General Motors divers performed such tasks on mechanical hardware.

(U) Figure 28 shows the deck layout for the first implantment attempt. During the second attempt, the large white crown-line buoys, on the port side, were removed in favor of jettisoning the crown lines instead of buoying them. In the vacated deck space glass buoyancy elements which had been stowed below deck during the first attempt were piled into large bins on deck for easier access.

(U) Transportainers, on the starboard side, housed electronics and mechanical shops and supplies. The winch inboard of the transportainers was carried for auxiliary purposes but was not used to any extent for the operation.

Handling Equipment

(U) Anchor crown lines constructed of nontorquing 3 by 19 wire rope of 1-inch diameter were used to lower the array anchors. Separate crown lines for each anchor were used as an alternative to relying upon acoustic releases for retrieval. This decision was made, secondly and very importantly, to avoid spending the several hours necessary to retrieve the lowered crown lines. Original plans prescribed bending the bitter ends of the crown lines to a 40,000-pound buoyancy float after anchor deployment. Thus it was envisioned that the anchors could be readjusted immediately after complete array implantment. This procedure was not followed because it would have been time consuming and was not considered necessary. Instead, upon bottoming of an anchor, the crown line was stretched away from the moor and cut loose to fall to the bottom of the ocean.

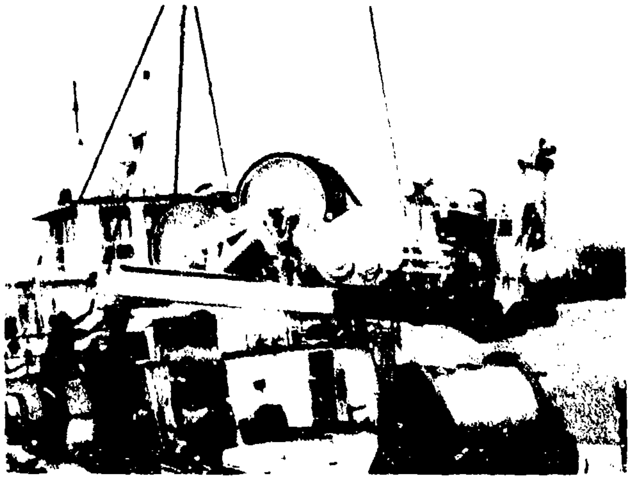


(U) Fig. 28 — Layout of equipment on the *Legbuilder's* main deck for the first implantment attempt

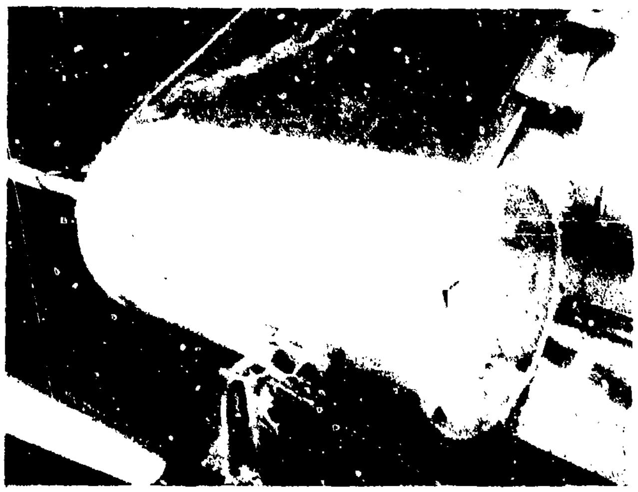
(U) The anchors were deployed by means of a multigrooved Pengo line-tensioning winch (Fig. 29) of 25,000 pounds capacity. This gasoline-engine-driven winch was positioned between the motorized crown-line reel stands and the stern roller and restrained the lowered anchor by means of a geared drive as well as a brake. The anchors were first lifted over the stern by means of the backhoe to a point where the load was taken by the winch. No difficulties occurred during the lowering of the anchors except that the load on the multigrooved winch caused its drum to tend to screw itself to starboard as the crown line passed over it.

(U) The crown lines were rated at 108,000 pounds tensile strength, which provided a factor of safety of about 5 at short stay and a factor of 2 at maximum depth, where dynamic loads could be absorbed over the 18,000 feet paid out. No tendancy to twist was observed when two of the crown lines were cut at deck level and when the third was cut at 15,000 feet below the surface by a hydraulic-actuated cable cutter.

(U) Two auxiliary moors were required during the Sea Spider implantment. One of these, a semitaut moor, was used as a marker buoy to affix moor center. The second, a slack moor of 1.4 scope was used to restrain the subsurface buoy during deployment of the array legs. Both of these moors were of the General Motors free-fall types, and both were deployed without incident and performed satisfactorily.



(U) Fig. 29 — Multigrooved tensioning winch for lowering the three main anchors



(U) Fig. 30 — Free-fall auxiliary anchor sliding into the water from the starboard gunwale of the *Rigbuilder*, whose bulwarks have been removed

(U) The free-fall moor (Fig. 30), consisted of a 6000-pound bull-nose clump upon whose after end was affixed an open-ended drum or bale. In the bale 3/8-inch-diameter 3 X 19 wire rope was coiled. Each turn consisted of inducing a 360° twist into the rope in the same manner that fiber rope is sometimes dispensed in chandleries by pulling the bitter end axially from inside the coil. This axial pulling simply takes out the twist which was put in during spooling. In the case of the General Motors system the coil was potted in fiberglass to prevent movement inside the bale. The anchor assembly was mounted transversely on skids at the gunwale, midships. The buoy was deployed first, and then the inboard end of the anchor skid was jacked up and the anchor skidded overboard, paying out the wire rope.

(U) In the case of the free-fall system for the semitaut marker buoy, a triggering device in the anchor assembly automatically stopped off the buoy line upon contact with the bottom. A subsurface buoy was shackled to the line and a nylon pendant was bent on between that buoy and a surface marker. The weight of the anchor line on the subsurface buoy caused it to sink below the surface.

(U) Project experience with both types of free-fall buoy systems confirms their reliability to withstand the natural forces of the sea in the deep ocean. A second navigation marker was necessary due to the first being removed by an identified foreign ship, which caused great implantment hardship to the project because of the limited weather-window available. The first buoy had been implanted at moor center after a bottom implantment-site resurvey 2 weeks before the incident.

(U) The restraining buoy system was installed at the beginning of the first implantment attempt and 6 weeks later was used again for the second attempt. At the outset of this second usage the buoy system was tested by the implantment vessel, *Rigbuilder*, by mooring to it overnight after pulling it by means of a pendant for 3 hours under tensions to 2000 pounds.

Implantment Procedure

(U) The implantment procedure proposed by IEC at the outset of the project was reconsidered many times during the development phase but was regarded as the most suitable and simple method for deployment. The method was predicated on the use of a single work vessel assisted by a navigation vessel, on anchor-and-crown-line lowering of the legs, and on the assistance of divers. The procedure assumed that the subsurface buoy could be pulled to 100 feet below the sea surface as part of the third-leg implantment procedure instead of winching it down to depth after the three main anchors were set.

(U) The basic procedure used in the initial implantment attempt consisted of the following sequential steps (variances which occurred in the second attempt will be stated in that discussion):

1. The *Sands* establishes moor center and locates it with a visual navigation marker buoy.

2. The *Rigbuilder* deploys an auxiliary mooring having surface expression at moor center for the purpose of restraining the Sea Spider subsurface buoy during implantment.

3. The *Rigbuilder* deploys the surface telemetry buoy and then the subsurface float with the northeast leg attached. The latter float is made fast to the restraining mooring by use of a pendant.

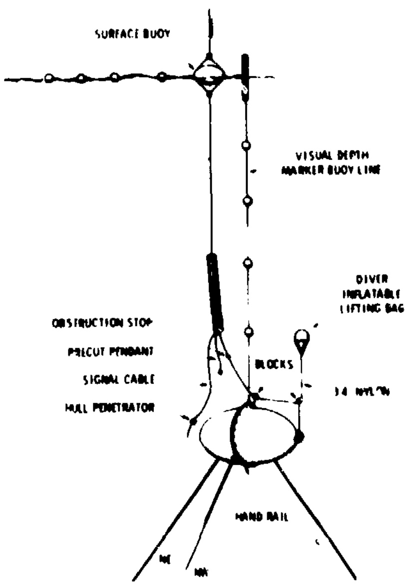
4. The *Rigbuilder* streams the northeast leg on the surface. The bitter end of the northeast leg is shackled to its anchor and lowered to the bottom using a crown line. The crown line is then jettisoned.

5. The *Rigbuilder* returns to moor center. Divers attach the south leg to the subsurface float. The *Rigbuilder* streams the leg, bends the bitter end to the anchor, and lowers the anchor to the bottom. The crown line is then jettisoned.

6. The *Rigbuilder* again returns to moor center. Divers attach the northwest leg. The *Rigbuilder* streams the leg and attaches the bitter end to the anchor. A transponder is affixed above the anchor for determining anchor elevation during lowering. By use of a crown line pulling against the moor, the anchor is emplaced so as to pull the subsurface buoy to a depth of about 100 feet.

7. Divers remove the temporary umbilical from the surface float and attach the permanent umbilical.

(U) Budgetary limitations prevented exact modeling of the implantment; however a pull-down experiment was run successfully on a wire-rope tri-moor in the Santa Barbara channel in 4000 feet of water. This moor was streamed by use of a Pengo line-tensioning winch similar to that used in Sea Spider. Successful application of that traction winch proved its merit for the Sea Spider deployment. In addition the operation provided for the testing of an elastic tether between the surface and subsurface buoy and the method of attaching the tether after the subsurface buoy was at design depth. This method made use of a diver air bag (Fig. 31) to tension the tether. The Santa Barbara channel experiment was successful. However, as hindsight has shown, parts of the system which ultimately offered the most difficulty during the Sea Spider implantment were not sufficiently tested.



(U) Fig. 31 — Use of an inflatable lifting bag to tension the surface buoy to the elastic umbilical-and-tether assembly

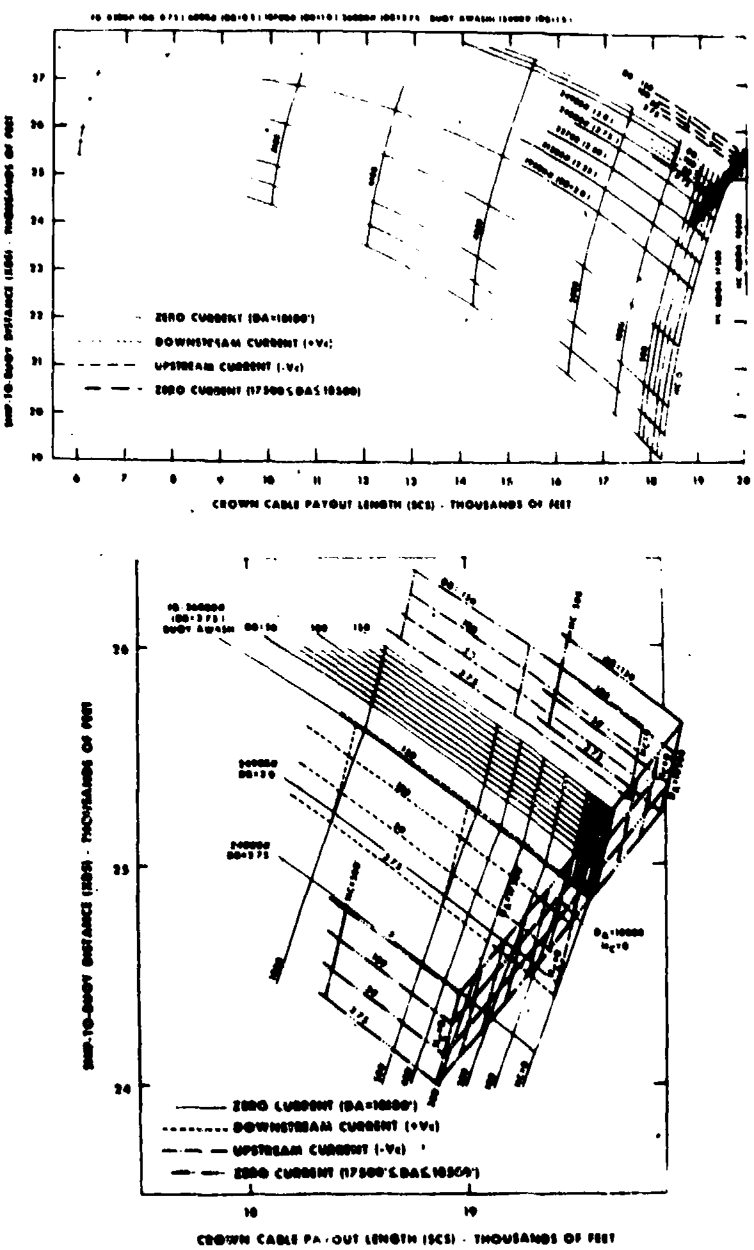
(U) The pulldown technique used in the channel experiment and in Sea Spider was predicated upon a computerized mathematical model of the current and restraining forces. From this model a set of working curves (Fig. 32) was drawn for at-sea personnel who would use them to fly-in the third leg anchor so that at its touchdown the subsurface float would be at the prescribed depth of 100 to 125 feet.

IMPLANTMENT ATTEMPTS

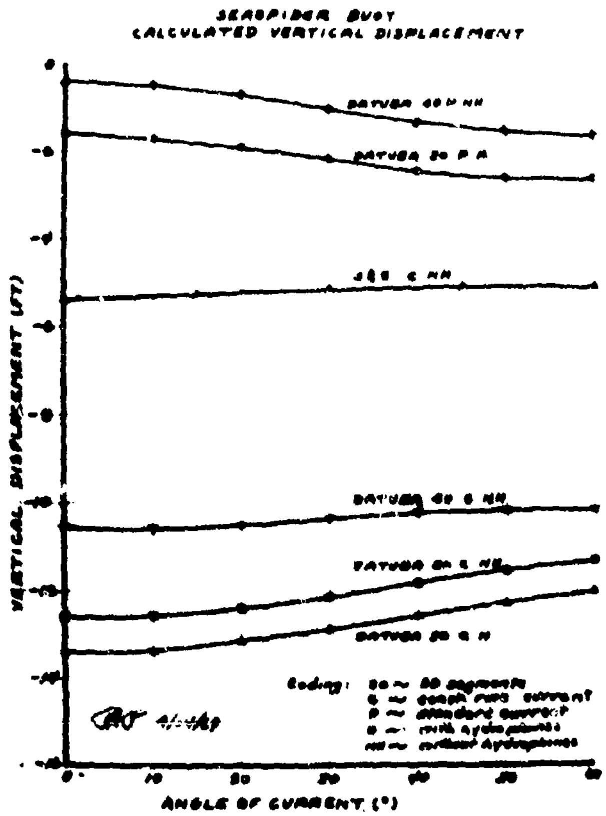
(U) The first attempt to install Sea Spider commenced at 0830 on 30 August 1969. The surface telemetry float was lifted into the water and tethered astern by its temporary umbilical, which was subsequently bent to the subsurface buoy upon the latter's deployment (Fig. 33). The subsurface buoy, with the surface float tethered to it, was made fast to the restraining buoy by a pendant comprising a long steel cable and a short length of nylon shock cord. The seas at the time were relatively low, and the operation of deploying the northeast leg progressed satisfactorily. During the afternoon the seas began to rise, and the weather deteriorated further during that night. By midnight, when 15,000 feet of array cable had been deployed, heavy seas broke the nylon shock cord. The prevailing seas carried the leg cable and the subsurface buoy toward the moored marker buoy, and by about 0100 on 31 August these had become entangled (Fig. 34). The buoys could not be separated immediately at first light of day because at that time the *Rigbuilder* had inadvertently snarled the leg cable in her screws, which casualty required several hours to repair. A team of three divers removed several hundred pounds of cable from the screws by use of bolt cutters (the rough seas and sharks notwithstanding). But this delay in regaining command of the vessel precluded chances for continuing the implant, because as a result of the entanglement a pad eye on the marker buoy had punctured the skin of the subsurface buoy. Equipment was retrieved (Fig. 35) with the exception of the marker and restraining buoy systems, and the *Rigbuilder* returned to Pearl Harbor with the subsurface float in tow.

(U) Subsequently the decision was made to repair the damage and return to station for a second implantment attempt. Certain modifications in the implantment technique were made to maximize chances for a successful operation.

(U) In addition to the location of moor center by a surface marker float, three acoustic transponders were placed on the ocean bottom so that the *Sands* could triangulate on them acoustically to more exactly position the *Rigbuilder* during anchor lowering. No hardware modifications of significance were accomplished except removing the top mast or VHF antenna from the telemetry buoy and fiberglassing that antenna to the lower mast. Certain changes were made in the deck arrangement such as removing the large crown-line buoys, so that the glass buoyancy floats could be located in close proximity to the deployment area.



(U) Fig. 32 — Working curves for at-sea use in flying-in the northwest anchor so as to pull the subsurface float to the depth of 100 to 125 feet



(U) Fig. 32 (Continued) — Working curves for at-sea use in flying-in the northwest anchor so as to pull the subsurface float to the depth of 100 to 125 feet

(U) Fig. 33 — Sequential views of the deployment of the subsurface buoy. The surface telemetry buoy has been deployed and is connected to the subsurface buoy.

(U) Fig. 33 (Continued) — Sequential views of the deployment of the subsurface buoy. The surface telemetry buoy has been deployed and is connected to the subsurface buoy.

(U) Fig. 34 — Subsurface buoy entangled against the marker buoy after breaking loose from the restraining moor

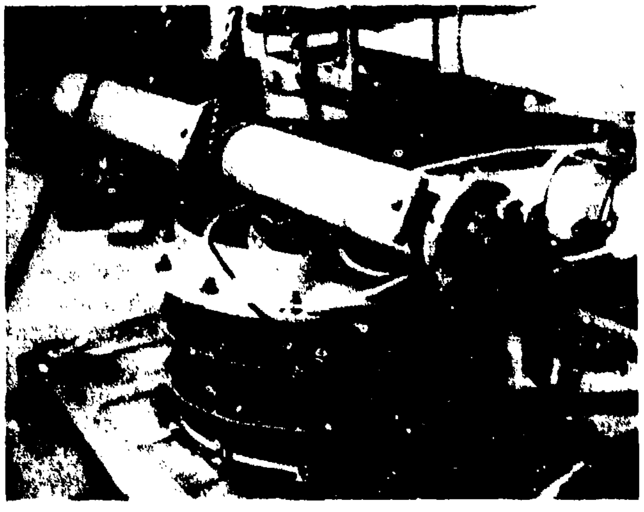
(U) Fig. 35 — Retrieval of the surface float in rough seas upon failure of the first implantment attempt

(U) At 0700 on Tuesday, 7 October, after 4 weeks of the repair, refurbishment, and minor modifications, a second attempt to install Sea Spider commenced. The seas were smooth, and the surface and subsurface buoys were successfully deployed from the *Rigbuilder* and tethered to the restraining buoy by a steel-wire pendant. This time the surface buoy was thethered in line between the other two buoys to preclude its tangling. Figure 36 shows these three buoys just prior to streaming the northeast leg, which was begun at 0800 and continued until 1900.

(U) During the streaming of the northeast leg various difficulties slowed the cable laying. The anticipated surface current of about 1 knot was absent. The only way to bloom the cable out on the surface to produce tension in it was to steam in a circle, thus creating an artificial current. One of the hydrophones stowed on the cable reel was torn from its mountings during deployment because gage marks which were intended to give advance warning of its emergence from the reel had been omitted inadvertently during the refurbishment of the cable at Pearl Harbor. Though the damage was rectified, 3 hours were lost in making the repairs. The sea was smooth, though a low swell was present, but a number of 16-inch-diameter buoyancy elements broke free of the array cable. In all cases the failure had been caused by hockling and fracture of their steel-wire tethers. It was apparent that this method of fastening floats was inadequate, particularly when the leg was on the surface.

(U) Deployment of the northeast-leg anchor started at 1900 and was completed 5 hours later. One hydrophone failed shortly after deployment of the leg, and the projector (Fig. 37) failed a few hours after the anchor reached the bottom. The time of this event is not known with certainty, but it occurred during the 24 hours after touchdown of the anchor. The projector failure was found afterward to be caused by a few ounces of water penetrating the seal of the electronic pressure housing; the same leak caused the explosive anchor release to fire, thus releasing the anchor.

(U) Fig. 36 — Restraining moor, telemetry buoy, and subsurface float tethered in tandem during the second implantment attempt with divers erecting the radar reflector on the subsurface float prior to the streaming of the northeast leg



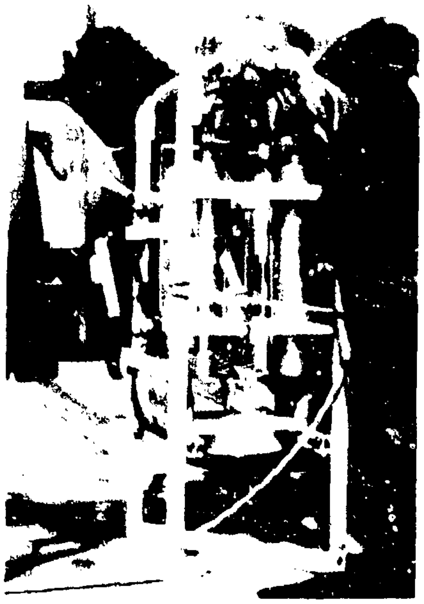
(U) Fig. 37 — One of the three acoustic projectors for locating the bottoms of the three legs. The long cylinder atop the projector houses its electronics package and an explosive anchor-release.

(U) Deployment of the south leg commenced at 0700 on Wednesday, 8 October. Seas were still calm, though the long swell had increased to a height of 10 feet. Because the surface currents were still low, the operation began by *Rigbuilder* steaming westerly from the subsurface buoy at moor center; this course caused the electrical coaxial connection from the south leg to be cut by a bracket on the bottom of that buoy. Repairs to this leg caused a 6-1/2-hour deployment delay. Advantage was taken of the delay to strengthen the pendants which secured the 16-inch buoyancy elements to the leg cables. At 1600, payout continued, and the leg was fully deployed on the surface and working at 0300, 9 October. The anchor was lowered successfully to the seabed by 0900.

(U) During that day the seas were rising, and the 1600 weather forecast predicted that a weather front would pass through the area by 1800, followed by sea state 4 conditions. Though this situation was highly unfavorable for deploying the third or northwest leg, the task was continued rather than to risk damage to the two legs already deployed. Difficulty had been experienced earlier with the temporary cables which connected the electrical terminations at the top end of the legs to the subsurface buoy during the installation operation. During the tests of the northwest leg (1630, 9 October) these cables failed because of mechanical damage and water penetration; consequently it was not possible to monitor the hydrophone signals during payout. Despite rising seas, work continued during the night, and the northwest leg was fully deployed on the surface by 0600, 10 October. The seas at this time were estimated to be sea state 5 with 35-knot winds and an average combined swell and wave height of 22 feet. The northeast anchor was then known to be disconnected, and many of the 16-inch buoyancy elements were adrift.

(U) Since the northeast leg was loose, it was decided to lower the northwest anchor in the same manner as the others and to pull down the array by means of the northeast leg (assuming it could be repaired or replaced). Thus the anchor altitude transponder (Fig. 38) was not attached to the base of the northwest leg as originally planned. By 1800 the northwest anchor touched bottom, and the crown line was cut using a pressure-actuated cutter which was slid down the line. The crown line was recovered during the night, since it was necessary to recover this last crown line to reuse it to reemplace the northeast leg and pull down the moor. Reorganization of the deck hardware and attempts to repair the temporary electrical installation cables took the entire following day, 11 October.

(U) Divers inspected the underside of the subsurface buoy early on Sunday, 12 October, and found the temporary electrical harness for the south leg broken. The cable was disconnected from the buoy and subsequent repairs were completed by 1100. Despite this repair all three legs were then inoperative because of damage to the temporary installation harness cables. Recovery of the northeast leg began at 1730. Only 2000 feet were recovered when it was found that the cable had been hockled in a number of places and had broken. All 16-inch buoyancy elements had broken loose, and the top hydrophone had broken free of the cable and was lost. During the day the University of New Hampshire was requested by radio to run a computer study to determine the motion of the moor with all 16-inch buoyancy elements missing. Results showed that the moor would not be stable and the subsurface buoy probably would be drawn down far below diving-depth limitations to its collapse depth. On 12 October the decision was made to terminate the operation and recover the moor.



(U) Fig. 38 — Anchor-altitude transponder intended to have been attached to the northwest leg if the first two legs had been pulled down successfully

(U) During recovery of the south leg it was found to be broken at 1200 feet from the buoy under conditions similar to those which were observed in the northeast leg. The northwest leg had not broken. However, because the explosive release mechanism failed to fire, it was not possible to disconnect the anchor by use of its release mechanism, and the cable had to be broken free of its anchor. The 800-foot steel-wire rope connecting the leg cable to the anchor chain broke at a load of 16,000 pounds measured at the surface. This was disturbing, because the cable was rated at 40,000 pounds. It was later found that the cable possibly had been damaged by a press-type cable grip at its lower end.

(U) On Tuesday, 14 October, all ships proceeded to Pearl Harbor, whereupon the implantment team was disbanded and the project equipment readied for shipment to the Naval Construction Batallion Center, Port Hueneme, for storage.

REFERENCES

1. "Biennial Report, 1960-71," Hawaii Institute of Geophysics, University of Hawaii, July 1971.
2. G.N. Sniffen and G.M. Savage, "Project Seaspider — Pacific, Analysis of the Motion of a Tri-Moored Buoy with Neutrally Buoyant Legs," University of New Hampshire Technical Report 104, Feb. 1968.
3. R.A. Skop and R.E. Kaplan, "The Static Configuration of a Tri-Moored Subsurface Buoy-Cable Array Acted on by Current-Induced Forces," NRL Report 6894, May 1969.

DEPARTMENT OF THE NAVY
OFFICE OF NAVAL RESEARCH
800 NORTH QUINCY STREET
ARLINGTON, VA 22217-5660

IN REPLY REFER TO
5510/1
Ser 93/160
10 Mar 99

From: Chief of Naval Research
To: Commander, Naval Meteorology and Oceanography Command
1020 Balch Boulevard
Stennis Space Center MS 39529-5005

Subj: DECLASSIFICATION OF PARKA I AND PARKA II REPORTS

Ref: (a) CNMOC ltr 3140 Ser 5/110 of 12 Aug 97

Encl: (1) Listing of Known Classified PARKA Reports

1. In response to reference (a), the Chief of Naval Operations (N874) has reviewed a number of Pacific Acoustic Research Kaneohe-Alaska (PARKA) Experiment documents and has determined that all PARKA I and PARKA II reports may be declassified and marked as follows:

   Classification changed to UNCLASSIFIED by authority of Chief of Naval Research letter Ser 93/160, 10 Mar 99.

   DISTRIBUTION STATEMENT A: Approved for public release. Distribution is unlimited.

2. Enclosure (1) is a listing of known classified PARKA reports. The marking on those documents should be changed as noted in paragraph 1 above. When other PARKA I and PARKA II reports are identified, their markings should be changed and a copy of the title page and a notation of how many pages the document contained should be provided to Chief of Naval Research (ONR 93), 800 N. Quincy Street, Arlington, VA 22217-5660. This will enable me to maintain a master list of downgraded PARKA reports.

3. Questions may be directed to the undersigned on (703) 696-4619, DSN 426-4619.

Peggy Lambert

PEGGY LAMBERT
By direction

Copy to:
NUWC Newport Technical Library (Code 5441)
NRL Washington (Mary Templeman, Code 5227)
NRL SSC (Roger Swanton, Code 7031)
✓DTIC (Bill Bush, DTIC-OCQ)

Continuation of LRAPP Final Report, February 1972, Contract N00014-71-C-0088, Bell Telephone Labs, Unknown # of pages
(NUSC NL Accession # 057708)

PARKA II-A, The Oceanographic Measurements, February 1972, MC Report 006, Volume 2, Maury Center for Ocean Science (ONR), 89 pages
(NUSC NL Accession # 059194) (NRL SSC Accession # 85007063)

Project Pacific Sea Spider - Technology Used in Developing A Deep-Ocean Ultrastable Platform, 12 April 1974, ONR-ACR-196, 55 pages
√ (DTIC # **529 945**)

LRAPP Program Review at the New London Laboratory, Naval Underwater Systems Center, 24 April 1975, NUSC-TD-4943, Unknown # of pages
(NUSC NL Accession # 004943)

An Analysis of PARKA IIA Data Using the AESD Parabolic Equation Model, December 1975, AESD Technical Note TN-75-09, Acoustic Environmental Support Detachment (ONR), 53 pages
(NRL SSC Accession # 85004613)

Bottom Loss Measurements in the Eastern Pacific Ocean, 26 January 1977, NADC-76320-20, 66 pages
(DTIC # **C009 224**)

PARKA I Oceanographic Data Compendium, November 1978, NORDA-TN-25, 579 pages
(DTIC # **B115 967**)

Sonar Surveillance Through A North Pacific Ocean Front, June 1981, NOSC-TR-682, 18 pages
(DTIC # **C026 529**)

The Acoustic Model Evaluation Committee (AMEC) Reports, Volume 1, Model Evaluation Methodology and Implementation, September 1982, NORDA-33-VOL-1, 46 pages
(DTIC # **C034 016**)

The Acoustic Model Evaluation Committee (AMEC) Reports, Volume 1A, Summary of Range Independent Environment Acoustic Propagation Data Sets, September 1982, NORDA-34-VOL-1A, 482 pages
(DTIC # **C034 017**)

The Acoustic Model Evaluation Committee (AMEC) Reports, Volume 2, The Evaluation of the Fact PL9D Transmission Loss Model, Book 1, September 1982, NORDA-35-VOL-2-BK-1, 179 pages
(DTIC # **C034 018**)

The Acoustic Model Evaluation Committee (AMEC) Reports, Volume 2, The Evaluation of the Fact PL9D Transmission Loss Model, Book 2, Appendices A-D, September 1982, NORDA-35-VOL-2-BK-2, 318 pages
(DTIC # **C034 019**)

DEPARTMENT OF THE NAVY
OFFICE OF NAVAL RESEARCH
875 NORTH RANDOLPH STREET
SUITE 1425
ARLINGTON VA 22203-1995

IN REPLY REFER TO:

5510/1
Ser 321OA/011/06
31 Jan 06

MEMORANDUM FOR DISTRIBUTION LIST

Subj: DECLASSIFICATION OF LONG RANGE ACOUSTIC PROPAGATION PROJECT (LRAPP) DOCUMENTS

Ref: (a) SECNAVINST 5510.36

Encl: (1) List of DECLASSIFIED LRAPP Documents

1. In accordance with reference (a), a declassification review has been conducted on a number of classified LRAPP documents.

2. The LRAPP documents listed in enclosure (1) have been downgraded to UNCLASSIFIED and have been approved for public release. These documents should be remarked as follows:

   Classification changed to UNCLASSIFIED by authority of the Chief of Naval Operations (N772) letter N772A/6U875630, 20 January 2006.

   DISTRIBUTION STATEMENT A: Approved for Public Release; Distribution is unlimited.

3. Questions may be directed to the undersigned on (703) 696-4619, DSN 426-4619.

B. F. LR

BRIAN LINK
By direction

Subj: DECLASSIFICATION OF LONG RANGE ACOUSTIC PROPAGATION PROJECT (LRAPP) DOCUMENTS

DISTRIBUTION LIST:

NAVOCEANO (Code N121LC – Jaime Ratliff)
NRL Washington (Code 5596.3 – Mary Templeman)
PEO LMW Det San Diego (PMS 181)
DTIC-OCQ (Larry Downing)
ARL, U of Texas
Blue Sea Corporation (Dr.Roy Gaul)
ONR 32B (CAPT Paul Stewart)
ONR 321OA (Dr. Ellen Livingston)
APL, U of Washington
APL, Johns Hopkins University
ARL, Penn State University
MPL of Scripps Institution of Oceanography
WHOI
NAVSEA
NAVAIR
NUWC
SAIC

Declassified LRAPP Documents

Report Number	Personal Author	Title	Publication Source (Originator)	Pub. Date	Current Availability	Class.
WHOI73-59	Tollios, C. D.	THE ACODAC DATA PROCESSING SYSTEM	Woods Hole Oceanographic Institution	730901	AD0773114; ND	U
Unavailable	Russell, J. J.	DOCUMENTATION FOR COMPUTER PROGRAM SUMMARY: A COMPUTER PROGRAM TO SUMMARIZE SOUND SPEED PROFILE DATA	Naval Undersea Center	731001	AD0918907	U
MC001Vol2	Unavailable	CHURCH ANCHOR DATA ANALYSIS PLAN VOL 2 (U)	Maury Center for Ocean Science	731001	ND	U
73-9M7-VERAY-R2	Jones, C. H.	LRAPP VERTICAL ARRAY- PHASE III	Westinghouse Research Laboratories	731105	ADA001130; ND	U
55	Weinstein, M. S., et al.	SUS QUALITY ASSESSMENT	Underwater Systems, Inc.	731201	ND	U
ARL-TM-73-42	Mitchell, S. K., et al.	QUALITY CONTROL ANALYSIS OF SUS PROCESSING FROM ACODAC DATA	University of Texas, Applied Research Laboratories	731220	ND	U
Unavailable	Daubin, S. C.	CHURCH GABBRO TECHNICAL NOTE: CONTINUOUS CURRENT PROFILES	University of Miami, Rosenstiel School of Marine and Atmospheric Science	740101	AD0775333	U
Unavailable	Bitterman, D. S.	ACODAC AMBIENT NOISE SYSTEM	Woods Hole Oceanographic Institution	740101	ADA009440	U
ONR MC-002 VOL. 2; XONICS 885	Unavailable	LONG RANGE ACOUSTIC PROPAGATION PROJECT (LRAPP). SQUARE DEAL DATA ANALYSIS PLAN (U) VOLUME 2 - ANNEXES	Maury Center for Ocean Science; Xonics, Inc.	740101	ND	U
ARL-TM-74-12	Groman, R. O., et al.	SPECIAL HARDWARE FOR ARL ANALYSIS OF ACODAC DATA	University of Texas, Applied Research Laboratories	740314	ADA000295; ND	U
Unavailable	Unavailable	ASEPS NEAR FIELD TRANSMISSION LOSS MODIFICATION, P-2205	Ocean Data Systems, Inc.	740401	ADA096583	U
Report 001; MSAG-1	Unavailable	MEASUREMENT SYSTEMS ADVISORY GROUP	Office of Naval Research	740401	ADA096586; ND	U
ACR-196	Gregory, J. B.	PROJECT PACIFIC SEA SPIDER, TECHNOLOGY USED IN DEVELOPING A DEEP-OCEAN ULTRASTABLE PLATFORM	Office of Naval Research	740412	AD0529945; ND	U
Unavailable	Gottwald, J. T.	ANNUAL REPORT FOR 1 MAY 1973 - 30 APRIL 1974	Tracor, Inc.	740524	AD0920210	U
Unavailable	Unavailable	ACOUSTIC MODEL SUPPORT ACTIVITIES, P-2220	Ocean Data Systems, Inc.	740530	ADA096584	U
HCI-CMC-18540	Daubin, S. C.	TRANSMISSION LOSS OF LOW FREQUENCY UNDERWATER SOUND IN THE CAYMAN TROUGH (CHURCH GABBRO TECHNICAL NOTE)	University of Miami, Rosenstiel School of Marine and Atmospheric Science	740601	ADC000424; ND	U
HCI-CMC-18343	Daubin, S. C.	AMBIENT NOISE IN THE NORTHWEST CARIBBEAN SEA (CHURCH GABBRO TECHNICAL NOTE) (U)	University of Miami, Rosenstiel School of Marine and Atmospheric Science	740601	ND	U
Unavailable	Barnes, A., et al.	DISCRETE SHIPPING MODEL	Planning Systems, Inc.	740604	ND	U